BTAG REVIEW DRAFT

June 18, 2008

PHASE II
SAMPLING AND ANALYSIS PLAN
FOR OPERABLE UNIT 3
LIBBY ASBESTOS SUPERFUND SITE

Part C: Ecological Data

Prepared by
U.S. Environmental Protection Agency
Region 8
Denver, CO

With Technical Assistance from:

Syracuse Research Corporation
Denver, CO

and

NewFields Boulder LLC
Boulder, CO

This page intentionally left blank to facilitate double-sided printing.

APPROVAL PAGE

Part C of the Phase II Sampling and Analysis Plan for Operable Unit 3 of the Libby Asbestos Superfund Site has been prepared by the U.S. Environmental Protection Agency, Region 8, with technical support from Syracuse Research Corporation and NewFields Boulder LLC, and is approved without conditions.

____ ________________

Bonita Lavelle Date
Remedial Project Manager, Libby OU3

This page intentionally left blank to facilitate double-sided printing.

Distribution List

Bonita Lavelle (3 copies)
U.S. Environmental Protection Agency
Region VIII
Denver, Colorado 80202-2466

David Charters (1 copy)
Superfund Ecological Risk Program
2890 Woodbridge Avenue
Building 18, MS-101
Edison, NJ 08837

Karen Nelson (1 copy)
U.S. Department of the Interior
Fish and Wildlife Service
Montana Field Office
585 Shepard Way
Helena, MT 59601

Robert Medler (1 copy)
Remedium Group, Inc.
6401 Poplar Avenue, Suite 301
Memphis, TN 38119

John Garr (1 copy)
Bruce Narloch (1 copy)
MWH Americas, Inc.
10619 South Jordan Gateway, Suite 100
Salt Lake City, UT 84095

Catherine LeCours (1 copy)
Montana Department of Environmental Quality
1100 North Last Chance Gulch
Helena, MT 59620

Bob Kirkpatrick (2 copies)
USDA Forest Service
Northern Region
200 East Broadway
Missoula, MT 59807

DOCUMENT REVISION LOG

Revision	Date	Primary Changes
0	05/14/2008	--

TABLE OF CONTENTS

This page intentionally left blank to facilitate double-sided printing.

LIST OF TABLES

This page intentionally left blank to facilitate double-sided printing.

LIST OF FIGURES

This page intentionally left blank to facilitate double-sided printing.

LIST OF ATTACHMENTS

This page intentionally left blank to facilitate double-sided printing.

LIST OF ACRONYMS

AOC	Administrative Order on Consent
CAR	Corrective Action Request
CCV	Continuing Calibration Verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
COC	Chain-of-Custody
CSM	Conceptual Site Model
DO	Dissolved Oxygen
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
EDXA	Energy Dispersive X-Ray Analysis
EPA	U.S. Environmental Protection Agency
EPH	Extractable Petroleum Hydrocarbons
FS	Feasibility Study
FSDS	Field Sample Data Sheets
FSP	Field Sampling Plan
FTP	File Transfer Protocol
GC/MS	Gas chromatography/mass spectroscopy
GO	Grid opening
GPS	Global Positioning System
GSD	geometric standard deviation
HASP	Health and Safety Plan
HQ	Hazard Quotient
ICV	Initial Calibration Verification
ID	Identification
IL	Inter-laboratory
ISO	International Organization for Standardization
IS	Internal Standard
KDC	Kootenai Development Corporation
LA	Libby Amphibole
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
MCE	Mixed Cellulose Ester
MCL	Maximum Contaminant Level
MDEQ	Montana Department of Environmental Quality
MFL	Million fibers per liter
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NVLAP	National Voluntary Laboratory Accreditation Program
OU	Operable Unit
PAH	Polyaromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PDF	Portable Document Format

LIST OF ACRONYMS (cont.)

PE	Performance Evaluation
PLM	Polarized Light Microscopy
PLM-VE	Polarized Light Microscopy Visual Area Estimation Method
PLN	Poisson lognormal
PR	Percent Recovery
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QATS	Quality Assurance Technical Support
QC	Quality Control
RD	Recount Different
RF	Response Factors
RI	Remedial Investigation
RPD	Relative Percent Difference
RPM	Remedial Project Manager
RS	Recount Same
RSD	Relative Standard Deviation
SAED	Selective Area Electron Diffraction
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SVOC	Semi-volatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
TEH	Total Extractable Hydrocarbons
TEM	Transmission Electron Microscopy
TRV	Toxicity Reference Value
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
VPH	Volatile Petroleum Hydrocarbons

PHASE II
SAMPLING AND ANALYSIS PLAN
FOR OPERABLE UNIT 3
LIBBY ASBESTOS SUPERFUND SITE

PART C: SAMPLING AND ANALYSES TO SUPPORT ECOLOGICAL RISK ASSESSMENT

1.0 PROJECT OVERVIEW

1.1 Purpose of this Document

This document is Part C of the Phase II Sampling and Analysis Plan (SAP) for the collection and analysis of samples to support a remedial investigation/feasibility study (RI/FS) within Operable Unit 3 (OU3) of the Libby Asbestos Superfund Site near Libby, Montana. OU3 includes the property in and around the former open pit vermiculite mine that is located northeast of the community of Libby, as well as the geographic area surrounding the former vermiculite mine that has been impacted by releases and subsequent migration of hazardous substances and/or pollutants or contaminants from the mine, including ponds, Rainy Creek, Carney Creek, Fleetwood Creek, and the Kootenai River. Rainy Creek Road is also included in OU3. The exact geographic area of OU3 has not yet been defined but will be based primarily upon the extent of contamination associated with releases from the former vermiculite mine as determined in the remedial investigation (RI) of OU3. The purpose of Part C of the Phase II SAP for OU3 is to guide the collection of data that will be used to assess the risks to ecological receptors associated with the release of mining-related contaminants to surface water, sediments, soils, air and biota. These data include information on sediment toxicity, benthic invertebrate community structure and function, fish populations, mammalian populations and histopathology and avian populations and histopathology. These data will be used to support an RI of OU3, the goal of which is to characterize the nature and extent of mining-related contamination in OU3, and to characterize the nature and level of risk posed by mining-related contamination to ecological receptors in OU3.

This SAP contains the elements required for both a field sampling plan (FSP) and quality assurance project plan (QAPP). This SAP has been developed in accordance with Environmental Protection Agency (EPA) Requirements for Quality Assurance Project Plans (EPA 2001) and the Guidance on Systematic Planning Using the Data Quality Objectives Process – EPA QA/G4 (EPA 2006). The SAP is organized as follows:

Section 1 – Project Overview
Section 2 – Background and Problem Definition

Section 3 – Summary of Phase I Data
Section 4 – Data Quality Objectives
Section 5 – Sampling Program Design
Section 6 – Sampling Method Requirements
Section 7 – Laboratory Testing Requirements
Section 8 – Analytical Methods Requirements
Section 9 – Quality Control
Section 10 – Data Management
Section 11 – Assessment and Oversight
Section 12 – Data Validation and Usability
Section 13 – References

1.2 Project Management and Organization

Project Management

EPA is the lead regulatory agency for Superfund activities within OU3. The EPA Remedial Project Manager (RPM) for OU3 is Bonita Lavelle, EPA Region 8. Ms. Lavelle is a principal data user and decision-maker for Superfund activities within OU3.

The Montana Department of Environmental Quality (MDEQ) is the support regulatory agency for Superfund activities within OU3. The MDEQ Project Manager for OU3 is Catherine LeCours. EPA will consult with MDEQ as provided for by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Contingency Plan, and applicable guidance in conducting Superfund activities within OU3.

EPA has entered into an Administrative Order on Consent (AOC) with Respondents W.R. Grace & Co.-Conn. and Kootenai Development Corporation (KDC). Under the terms of the AOC, W.R. Grace & Co.-Conn. and KDC will implement this SAP. The designated Project Coordinator for Respondents W.R. Grace & Co.-Conn. and KDC is Robert Medler of Remedium Group, Inc.

Technical Support

EPA will be supported in this project by a number of contractors, including:

- Syracuse Research Corporation (SRC) will assist in the development of sampling and analysis plans, in the evaluation and interpretation of the data, and preparation of the baseline risk assessments for OU3.

- NewFields Boulder LLC, working as a subcontractor to SRC, will provide support in development of sampling and analysis plans, evaluation and interpretation of data, mapping and other GIS applications, and design and evaluation of the feasibility study.

Field Sampling Activities

All field sampling activities described in this SAP will be performed by W.R. Grace & Co.-Conn. and KDC, in strict accord with the sampling plans developed by EPA. W.R. Grace & Co.-Conn. and KDC will be supported in this field work by MWH Americas, Inc. (MWH). Individuals responsible for implementation of field sampling activities are listed below:

- MWH Project Director: Michael DeDen
- MWH Project Manager: John D. Garr
- MWH Field Quality Control Officer: Jeremy S. Collyard
- MWH Quality Assurance Officer: Stephanie A. Boehnke

On-Site Field Coordinator

Access to the mine is currently restricted and is controlled by EPA. The on-site point of contact for access to the mine is Courtney Zamora of the U.S. Department of Transportation, John A. Volpe National Transportation Systems Center (Volpe).

Sample Preparation and Analysis

All samples collected as part of the Phase II investigation will be sent for preparation and/or analysis at laboratories selected and approved by EPA.

- All analyses of sediment samples for asbestos will be performed by EMSL Analytical, Inc.
- All samples of tissue to be analyzed for asbestos will be performed by EMSL Analytical, Inc.
- All analyses of samples for non-asbestos analytes will be performed by Energy Laboratories, Inc. (ELI)
- All samples of soil or soil-like media to be analyzed for asbestos will be prepared for analysis by EPA's soil preparation facility in Denver, CO, operated by CDM.
- All validation and verification activities for asbestos and non-asbestos data will be performed by SRC or their subcontractors.
- All histology samples will be analyzed by ?
- All benthic invertebrate samples will be processed and identified by ?

Data Management

Administration of the master OU3 database for OU3 will be performed by EPA contractors (SRC and NewFields). The primary database administrator will be Lynn Woodbury. She will be responsible for sample tracking, uploading new data, performing error checks to identify inconsistent or missing data, and ensuring that all questionable data are checked and corrected as needed. When the OU3 database has been populated, checked and validated, relevant asbestos data will be transferred into the Libby2 database for final storage.

2.0 BACKGROUND AND PROBLEM DEFINITION

2.1 Site Description

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. Vermiculite from the mine at Libby is known to be contaminated with amphibole asbestos that includes several different mineralogical classifications, including richterite, winchite, actinolite and tremolite. For the purposes of EPA investigations at the Libby Superfund Site, this mixture is referred to as Libby Amphibole (LA).

Historic mining, milling, and processing of vermiculite at the site are known to have caused releases of vermiculite and LA to the environment. Inhalation of LA associated with the vermiculite is known to have caused a range of adverse health effects in exposed humans, including workers at the mine and processing facilities (Amandus and Wheeler 1987, McDonald et al. 1986, McDonald et al. 2004, Sullivan 2007, Rohs et al. 2007), as well as residents of Libby (Peipens et al. 2003). Based on these adverse effects, EPA listed the Libby Asbestos Site on the National Priorities List in October 2002.

Starting in 2000, EPA began taking a range of cleanup actions at the site to eliminate sources of LA exposure to area residents and workers using CERCLA (or Superfund) authority. Given the size and complexity of the Libby Asbestos Site, EPA designated a number of Operable Units (OUs). In the early stages, efforts were focused mainly on wastes remaining at former vermiculite processing areas including OU1 (the export plant) and OU2 (the screening plant). As work progressed, attention shifted to cleanup of current homes and workplaces in the main residential/commercial areas of Libby, designated by EPA as OU4. To date, Superfund investigation and cleanup activities have been conducted by EPA within OU4 and some of the historic processing areas in and around the town of Libby. Environmental investigations of the nearby town of Troy, designated as OU7, began in the summer of 2007. The Phase I RI for OU3 was implemented in September – October of 2007.

Figure 2-1 shows the location of the mine and a preliminary study area boundary for OU3. EPA established the preliminary study area boundary for the purpose of planning and developing the scope of the RI/FS for OU3. This study area boundary may be revised as data are obtained during the RI for OU3 on the nature and extent of environmental contamination associated with releases that may have occurred from the mine site.

2.2 Basis for Concern at OU3

EPA is concerned with environmental contamination in OU3 because the area is used by humans for logging and a variety of recreational activities, and also because the area is habitat for a wide range of ecological receptors (both aquatic and terrestrial). Contaminants of potential concern to EPA in OU3 include not only LA, but any other mining-related contaminants that may have been released to the environment.

2.3 Scope and Strategy of the RI at OU3

As noted above, EPA is conducting an RI in OU3 in order to characterize the nature and extent of environmental contamination in OU3 and to evaluate risks to humans and ecological receptors from mining-related contaminants in the environment.

Respondents W.R. Grace & Co.-Conn. and KDC performed the first round of RI sampling (referred to as Phase I) in OU3 in the fall of 2007 in accord with the Phase I Sampling and Analysis Plan for Operable Unit 3 (USEPA 2007). The primary goal of the Phase I investigation was to obtain preliminary data on the levels and spatial distribution of asbestos and also other non-asbestos contaminants that might have been released to the environment in the past as a consequence of the mining and milling activities at the site.

One component of the RI at OU3 includes characterizing exposure and risk to aquatic receptors that reside in surface water bodies that may be impacted by releases from the mined area. This includes the waters of Fleetwood Creek, Carney Creek, Rainy Creek, the on-site tailings and Mill Ponds, and potentially (if data indicate), the Kootenai River. Typically, water flow in these surface water features varies seasonally, being highest during the spring snowmelt period. Variation in water flow rate is potentially important because flow might have significant effects on the concentrations and amounts of asbestos and/or non-asbestos contaminants being carried by the water. It is not known if asbestos or any other constituent will show similar patterns in the Rainy Creek watershed, but if such seasonal variations do occur, it is important to characterize the timing and magnitude of the variations. For this reason, a Phase IIA sampling and analysis plan for surface water and sediment (USEPA, 2008a) was prepared (ahead of other components) to ensure that sample collection can include the spring runoff period.

One component of the RI at OU3 includes characterizing exposure and risk to human receptors that may be impacted by releases from the mined area. A Phase IIB sampling and analyses plan was prepared to describe the collection of data to support the characterization of exposure and risks to human health (USEPA, 2008b).

An additional component of the RI at OU3 includes characterizing exposure and risk to ecological receptors other than those addressed by the Phase IIA SAP. This Phase IIC sampling and analyses plan is prepared to describe the collection of data to support the characterization of exposure and risk to aquatic receptors exposed to sediments and terrestrial wildlife that may be exposed to environmental media impacted by releases from the mined area.

A Problem Formulation document has been prepared by EPA (USEPA, 2008c) which represents the systematic planning step that identifies the major concerns and issues to be considered in the ecological risk assessment (ERA) and describes the basic approaches that will be used to characterize ecological risks. The Problem Formulation identifies the ecological setting at OU3, the nature of contamination and the ecological receptors that may come into contact with contaminated media. Conceptual site models (CSMs) are developed that summarize the understanding of contaminant sources, fate and transport pathways, and exposure pathways that are possible for each group of ecological receptors. Risk management objectives for OU3 are identified as well as risk management goals and the general strategies that are available to assess risks for ecological receptors.

The Problem Formulation reviews the strategies that are available for the evaluation of risks to ecological receptors from non-asbestos and asbestos contamination at OU3. The Phase IIC SAP represents implementation of a subset of elements of the presented strategies. Additional elements may be implanted as described in additional SAPs as they are deemed useful.

This page intentionally left blank to facilitate double-sided printing.

3.0 SUMMARY OF PHASE I DATA

Detailed data from the Phase I investigation for both asbestos and non-asbestos analytes are provided in Attachment A.1. Attachment A.2 presents a summary and interpretation of the quality control samples collected as part of the Phase I investigation that are specific to the mine waste, forest soil and tree bark results discussed below. Detailed surface water and sediment data and interpretation of the quality control samples specific to surface water and sediment from the Phase I investigation for both asbestos and non-asbestos analytes are available in the Phase II SAP (Part A) (USEPA, 2008a). The following sections summarize the sampling and analytical results of the Phase I investigation. Data reported here include summary statistics on the detection frequency and observed levels of each analyte evaluated in each medium (surface water, sediment, mine waste, forest soil, duff, and tree bark).

In considering these data, it is important to note that detection of a chemical in a site medium may not indicate that a release has occurred, since many of the detected chemicals occur naturally in the environment. In addition, concentration values may tend to vary over geographic area and time (e.g., concentrations may potentially be higher during spring runoff than during the fall). Therefore, it is important to collect data that provide adequate spatial and temporal representativeness before comparing to benchmarks or using the data to assess potential risk to humans or environmental receptors.

3.1 Surface Water

Sampling Stations

During Phase I, surface water samples were collected at a total of 24 locations, as shown in Figure 3-1. As seen, sampling stations include a number of locations along Carney Creek, Fleetwood Creek, and Rainy Creek, including ponds and impoundments on these streams, as well as seeps and springs that were located nearby.

Chemical Analyses

All surface water samples collected during Phase I were analyzed for asbestos, metals and metalloids, petroleum hydrocarbons, anions, and other water quality parameters. In addition, several selected surface water samples were analyzed for a broad suite of other chemicals, including volatile organic chemicals (VOCs), semi-volatile organic chemicals (SVOCs), pesticides, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), nitrogen-containing compounds, and selected radionuclides. These locations were selected specifically to characterize waters generated by the confluence of flows from the upper and lower portions of the mined area. Table 3-1 lists the analytical methods that were employed, and Table 3-2 shows the analyses that were performed at each station.

Asbestos Results for Phase I

Table 3-3 summarizes the results of the analysis of surface water and seeps for asbestos (LA). Results are expressed in terms of million fibers per liter (MFL). As seen, concentration values of total LA ranged widely (more than four orders of magnitude), from < 0.1 to 125 MFL.

Figure 3-2 is a map that displays the spatial pattern of results. The highest levels were observed in samples located in ponds or impoundments, including the tailings impoundment, the Mill Pond, and the pond on Fleetwood Creek, as well as from several seeps along the south side of the mined area. Levels of LA in the ponds exceed the current MCL of 7 MFL based on particles longer than 10 um. Levels in lower Rainy Creek (below the Mill Pond) tended to be relatively low. A sample collected just upstream of the confluence of Rainy Creek and the Kootenai River was non-detect.

Nonasbestos Results for Phase I

Table 3-4 presents summary statistics on the frequency and level of analytes detected in surface water samples analyzed as part of the Phase I investigation. As seen, a number of inorganic constituents (metals, anions, and nitrogen compounds) were detected, as were several indicators of petroleum hydrocarbons, but no VOCs, SVOCs, PCBs, or PAHs were detected.

3.2 Sediment

Sampling Stations

During Phase I, sediment samples were collected at a total of 24 locations, as shown in Figure 3-1. As seen, sampling stations include a number of locations along Carney Creek, Fleetwood Creek, and Rainy Creek, including ponds and impoundments on these streams, as well as seeps and springs that were located nearby.

Chemical Analyses

All sediment samples collected during Phase I were analyzed for asbestos, metals and metalloids, petroleum hydrocarbons, and several sediment quality parameters. In addition, several selected sediment samples were analyzed for a broad suite of other chemicals, including cyanide, pesticides, PCBs, VOCs, SVOCs, and PAHs. Table 3-5 lists the analytical methods that were employed, and Table 3-6 shows the analyses that were performed at each station.

Asbestos Results for Phase I

Sediment samples were divided into two fractions (coarse and fine) by sieving. Concentrations of LA in the coarse fraction were measured gravimetrically and expressed as a mass percent (grams of LA per 100 grams of coarse fraction). Concentrations in the fine fraction were measured using polarized light microscopy using a visual area estimation approach (PLM-VE). Results for PLM-VE are expressed as mass percent if the concentration is 1% or higher (Bin C). If the estimated concentration is <1%, the results are expressed semi-quantitatively, according to the following scheme:

PLM-VE Result	Range of Mass Percent
Bin A (ND)	None detected (likely < 0.05%)
Bin B1 (Trace)	LA detected, > 0% but < 0.2%
Bin B2 (<1%)	LA detected, >0.2% but < 1%
>1%	Results presented as percentage without qualifier

Table 3-7 summarizes the analytical results for asbestos (LA) in sediment. As seen, nearly all (22 out of 24) of the sediment samples collected contain LA. In the fine fraction, values ranged from trace (<0.2%) up to 7%. In the coarse fraction, levels generally ranged from 0.1% to 0.5%.

Figure 3-3 shows the spatial pattern of LA in the fine fraction of sediment. As shown, LA was detected in most samples, except those collected in the upper-most reaches of Rainy Creek and Fleetwood Creek. Concentrations of 1% or higher (Bin C) were detected in multiple locations. The highest levels observed were in samples collected from on-site seeps.

Nonasbestos Results for Phase I

Table 3-8 summarizes the results for analytes detected in sediment samples analyzed as part of the Phase I investigation. As seen, a number of inorganic constituents were detected, as were several indicators of petroleum hydrocarbons. The laboratory noted that the composition of some of the petroleum hydrocarbons detected did not resemble the composition expected for man-made fuels, and might be natural in origin. In addition, methyl acetate was detected in two samples, and pyrene was detected in one sample. All other chemical analytes were not detected in any sample. The following table compares the maximum detected sediment concentration for each analyte (detected) to screening benchmarks for toxicity to benthic invertebrates. These benchmarks are reviewed and listed in the Problem Formulation document for OU3 (USEPA, 2008c). Three maximum detected concentrations of metals exceed respective probable effects concentrations including chromium, manganese, and nickel. The concentrations for these metals are plotted geographically in Figure 3-4.

Category	Detected Analytes	Max Concentration	Screening Benchmarks (mg/kg)		Exceedances	
			TEC	PEC	TEC	PEC
Metals	Aluminum	27,500	25,519	59,572	X	
	Arsenic	7	10	33		
	Barium	1,520	--	--		
	Chromium	289	43	111	X	X
	Cobalt	42	--	--		
	Copper	66	32	149	X	
	Iron	39,600	188,400	247,600		
	Lead	100	36	128	X	
	Manganese	12,700	631	1,184	X	X
	Mercury	0.1	0.2	1		
	Nickel	82	23	49	X	X
	Selenium	1.2	--	--		
	Thallium	0.9	--	--		
	Vanadium	80	--	--		
	Zinc	50	121	459		
PAH	Pyrene	0.0049	0.2	2		
VOC	Methyl acetate	0.37	--	--		

TEC = Threshold Effect Concentrations (USEPA, 2008)
PEC = Probable Effect Concentrations

As noted above, it is not appropriate to draw any strong conclusions regarding whether or not a release has occurred or whether any of the values are of potential concern until additional data are collected to ensure adequate representativeness of the data.

3.2 Mine Waste/Site Soils

Sampling Stations

During Phase I, mine waste and/or soil samples were collected at several locations as shown in Figure 3-5. These samples focused on each of the principal mine waste materials identified to date including mine waste rock, impounded tailings, and coarse tailings as well soils in the former mill area and materials used for construction of unpaved sections of Rainy Creek Road. These samples are divided into six categories:

Road	MS-1 to MS-2
Tailings Impoundment	MS-4 and M-5
Coarse Tailings	MS-6 to MS-9
Cover Material	MS-10 to MS-13; MS-21 to MS-24
Waste Rock	MS-14 to MS-20; MS-26 to MS-30; MS-32
Outcrop	MS-25; MS-31; MS-33-38

Chemical Analyses

All mine waste and soil samples were analyzed for asbestos, metals and metalloids, petroleum hydrocarbons, as well as pH, moisture content and organic carbon content. This was with the exception of outcrop samples which were not analyzed for petroleum hydrocarbons. In addition, several selected mine waste and soil samples were analyzed for a broad suite of other chemicals. Table 3-9 lists the analytical methods that were used, and Table 3-10 shows the analyses that were performed at each sampling location.

Asbestos Results for Phase I

Similar to sediment samples, mine waste samples were divided into two fractions (coarse and fine) by sieving and analyzed as described above. Table 3-11 and Figure 3-6 summarize the results of the analysis of asbestos (LA) in mine waste and soil samples. All but one soil sample (33 of 34) contained LA. Of these, two are classified as Bin B1 (<0.2%), 26 are classified as Bin B2 (0.2% to 1%), and 5 are estimated to contain levels from 2-8%.

Nonasbestos Results for Phase I

The results of the analyses of the Phase I mine waste and soil samples are provided in Table 3-12. The results listed in the table are those for analytes that were detected in at least one mine waste or soil sample. The full results of the analyses from the Phase 1 sampling program are included in Attachment A. Fifteen metals, eight PAHs, one pesticide (pentachlorophenol), one VOC (methylacetate), aromatic and aliphatic hydrocarbons, total extractable hydrocarbons (TEH), toluene and total purgeable hydrocarbons were detected. PCBs and SVOCs were not detected in any of the mine waste and soil samples.

3.3 Tree Bark

Sampling Stations

Tree bark samples were collected along a number of transects that radiate away from the mine, with special emphasis on the predominant downwind direction (northeast) as shown in Figure 3-7.

Tree bark samples were targeted for collection from Douglas fir trees ranging in size from 8-10 inches in diameter at a sampling height of 4-5 ft. This size recommendation was made based on the assumption of a correlation between size and age, and that trees ranging in size from 8-10 inches in diameter were at least 30 years old, and hence would have been exposed to airborne releases during mining operations.

In the field, all tree bark samples were collected from Douglas fir trees at a height of 4-5 ft. In three instances (SL15-06, SL75-13 and SL197-07), no trees of 8 inches in diameter were located near transect sampling points, so smaller trees were sampled (6.7, 7.1 and 7.0 inches in diameter, respectively). In addition, only larger trees (>10 inches in diameter) were available for sampling near transect sampling points at 47 other stations (MWH, 2007).

One to two tree cores were collected per transect (10%) to allow an evaluation of tree age. This was successfully implemented in the field, resulting in age data for 12 of the 74 trees for which tree bark was sampled (16%).

Chemical Analysis

All tree bark samples were analyzed for asbestos. Tree cores were transmitted to the Laboratory of Tree-Ring Research at the University of Arizona for age analysis by counting of tree rings.

Asbestos Results for Phase I

Table 3-14 presents the results, expressed as million LA fibers per cm^2. Figure 3-8 plots actual sampling locations and indicates the results using a color-coding system. Figure 3-9 to 3-15 plot the data for each transect, incorporating the surface topography along the transect. The raw TEM data from the analysis are provided in Attachment A.1 along with micrographs in Attachment A.2, and EDXA spectra in Attachment A.3.

As shown, the data show a substantial degree of variability, but there is a general tendency for the highest values to occur in samples collected within a few miles of the mine. One exception occurs along the transect located upwind from the mine site (SL255), where the highest concentration of LA was observed in the tree bark sample collected the farthest away from the mine site. This may be attributable to sources other than releases from the mined area.

Age Data

Data on tree age generated by tree core analysis are presented in Table 3-15. As seen, the minimum age was 29 years, the maximum was 100 years, and the average was 69 years. Figure 3-16 plots the amount of LA in the bark as a function of age. As seen, there is an upward tendency, but the relationship is not strong. This is not unexpected, because the amount of LA in bark is assumed to depend not only on age but also distance and direction from the mine.

3.4 Forest Soils and Duff

Sampling Stations

Forest soil and duff samples were collected from approximately equally spaced locations around the perimeter of a circle with a radius of about 5 feet, centered on the same tree where the bark sample was collected (see Figure 3-7).

Chemical Analyses

The forest soil samples were divided into two fractions (coarse and fine) by sieving and analytical results were reported as described above for sediment samples analyzed for LA. Duff samples were prepared by high temperature ashing to remove organic matter. The residue was then analyzed for LA by TEM. Results for duff samples are reported as a mass fraction of the mass of asbestos in grams to the mass of dried duff in grams.

Asbestos Results for Phase I

The results for analyses of asbestos in forest soils are provided in Table 3-13 and are plotted in Figure 3-17. As seen, LA was detected in a number of soil samples located relatively close to the mined area, but was not detectable at a distance more than about 2 miles from the mined area. Only one sample collected from a location approximately 1/5 mile across gradient downwind from the mine area had levels of LA qualified in Bin C (6% MF_{LA} in the fine fraction and 1.3% MF_{LA} in the coarse fraction). The source of the LA observed at these locations is unknown, but might include a) naturally occurring outcrops of the LA-bearing ore body, b) deposition from historic airborne releases from the mine and mill, and c) water-based erosion from past and/or present materials at the mine site.

The full results of the duff samples are not yet available, but preliminary data suggest that LA is observable in duff samples.

This page intentionally left blank to facilitate double-sided printing.

4.0 DATA QUALITY OBJECTIVES

4.1 Overview of the DQO Process

Data Quality Objectives (DQOs) define the type, quality, quantity, purpose, and intended uses of data to be collected (EPA, 2006). The design of a study is closely tied to its DQOs, which serve as the basis for important decisions regarding key design features such as the number and location of samples to be collected and the analyses to be performed. In brief, the DQO process typically follows a seven-step procedure, as follows:

1. State the problem that the study is designed to address
2. Identify the decisions to be made with the data obtained
3. Identify the types of data inputs needed to make the decision
4. Define the bounds (in space and time) of the study
5. Define the decision rule which will be used to make decisions
6. Define the acceptable limits on decision errors
7. Optimize the design using information identified in Steps 1-6

Following these seven steps helps ensure that the project plan is carefully thought out and that the data collected will provide sufficient information to support the key decisions which must be made.

4.2 Conceptual Site Models

The conceptual site model (CSM) is a schematic summary of what is known about the nature of source materials at a site, the pathways by which contaminants may migrate through the environment, and the scenarios by which receptors may be exposed to site-related contaminants.

Figure 4-1 presents the CSM for exposure of each general ecological receptor group (fish, benthic invertebrates, terrestrial plants, soil invertebrates, birds and mammals and amphibians) to non-asbestos mining-related contaminants. As seen, each receptor group may be exposed by several different pathways. However, not all pathways are equally likely to be important. In each CSM, pathways are divided into three main categories:

- A solid black circle (●) represents pathways that are believed to be complete, and which may provide an important contribution to the total risk to a receptor group.

- An open circle (O) represents an exposure pathway that is believed to be complete, but which is unlikely to be a major contributor to the total risk to a receptor group, at least in comparison to one or more other pathways that are evaluated.

- An open box represents an exposure pathway that is believed to be incomplete (now and in the future). Thus, this pathway is not assessed.

Figure 4-2 presents the CSM for exposure to asbestos. This CSM is similar to the one for non-asbestos (Figure 4-1), except that information is not generally available to characterize the relative importance of each of the various pathways by which a receptor may be exposed. For this reason, the open circle is only used for direct contact (dermal exposure) of birds and mammals with asbestos. However, it should still be understood that not all of the exposure pathways indicated by a black circle for a receptor are likely to be of equal concern.

The following sections provide a more detailed discussion of the main elements of these CSMs.

Potential Sources of Contamination

The main sources of asbestos contamination at this site are the mine wastes generated by historic vermiculite mining and milling activities. This includes piles of waste rock and waste ore at on-site locations, as well as the coarse tailings pile and the fine tailings impoundment. These wastes may also be sources of metals and other inorganic constituents of the ore. In addition, some chemicals used at the mine site in the processing of vermiculite ore might also be present in onsite wastes, including diesel fuel, alkyl amines, fluorosilicic acid, and various other flocculants, defoamers, frothers and other reagents.

Migration Pathways in the Environment

From the sources, contaminants may be released and transported via airborne emissions, surface water transport or food chain transport.

> *Airborne Transport*. Contaminants may become suspended in air and transported from sources via release mechanisms such as wind, mechanical disturbances and/or erosion. Once airborne, contaminants may move with the air and then settle and become deposited onto surface soils. This pathway is likely to be important for asbestos, but is thought to be of low concern for non-asbestos contaminants.
>
> *Surface Transport*. Contaminants may be carried in surface water runoff (e.g., from rain or snowmelt) from the mine or other areas where soil is contaminated, and become deposited in soils or sediments at downstream locations. This pathway is equally applicable to both asbestos and non-asbestos contaminants.
>
> *Food Chain Transport*. Contaminants may be taken up from water, sediment or soil into the tissues of aquatic or terrestrial organisms from water and/or sediment and/or soils and/or prey items into prey items (fish, benthic invertebrate, plants, soil invertebrates, birds, mammals). This is applicable to both asbestos and non-asbestos contaminants.

Potentially Exposed Ecological Receptors

There are a large number of ecological species that are likely to occur in OU3 and that could be exposed to mine-related contaminants. However, it is generally not feasible or necessary to evaluate risks to each species individually. Rather, it is usually appropriate to group receptors with similar behaviors and exposure patterns, and to evaluate the risks to each group.

For aquatic receptors, organisms are grouped into two categories:

- Fish
- Benthic macroinvertebrates

For terrestrial receptors, organisms are grouped into five broad categories:

- Terrestrial Plants
- Soil invertebrates
- Birds
- Mammals
- Amphibians

Exposure Pathways of Primary Concern

<u>Terrestrial Plants and Soil Invertebrates</u>. Terrestrial plants and soil-dwelling invertebrates (e.g., worms) are exposed mainly by direct contact with contaminants in soil. Exposure of plants may also occur due to deposition of contaminated dust on foliar (leaf) surfaces, but this pathway is generally believed to be small compared to root exposure.

<u>Fish.</u> The primary exposure pathway for fish is direct contact with contaminants in surface water. This is applicable to both asbestos and non-asbestos contaminants. Fish may also be exposed to contaminants by ingestion of contaminated prey items, and incidental ingestion of sediment while feeding. Direct contact with sediment may also occur. This is often assumed to be minor compared to the pathways above.

<u>Benthic Invertebrates</u>. Benthic invertebrates may be exposed to contaminants in surface water and/or sediment via ingestion and/or direct contact. Benthic invertebrates may also be exposed to contaminants via ingestion of aquatic prey items that have accumulated contaminants in their tissues. This is applicable to both asbestos and non-asbestos contaminants.

<u>Mammals and Birds</u>. Mammals and birds may be exposed to asbestos and non-asbestos contaminants via ingestion of soils, surface water, sediment and food. Mammals and birds may also be exposed to asbestos by inhalation exposures when feeding or foraging activities result in the disturbance of asbestos-contaminated soils, sediments or other media. Direct contact (i.e.,

dermal exposure) of birds and mammals to soils may occur in some cases, but these exposures are usually considered to be minor in comparison to exposures from ingestion (USEPA, 2003). Likewise, inhalation exposure to non-asbestos contaminants in airborne dusts is possible for all birds and mammals, but this pathway is generally considered to be minor compared to ingestion pathways (USEPA, 2003).

Amphibians. Amphibians (frogs, toads) inhabit both aquatic and terrestrial (mainly riparian) environments with early life stages being primarily aquatic and latter life stages primarily terrestrial. Amphibians in their early aquatic life stages may be exposed to contaminants in surface water via ingestion and direct contact. They may also be exposed to contaminants in sediment via ingestion and direct contact and to contaminants in aquatic prey items via ingestion. In the terrestrial (riparian) environment, amphibians may be exposed to contaminants in soils or sediments via ingestion, inhalation and/or direct contact and also as the result of ingestion of terrestrial prey items.

4.3. Data Quality Objectives

4.3.1 State the Problem

Mining operations at the Site have resulted in the release of various types of asbestos and non-asbestos to the environment, including surface water, sediment and soils. Data on the effects of asbestos (LA) and non-asbestos contaminants are not sufficient to allow for a reliable assessment of risks to ecological receptors.

4.3.2 Identify the Decision

Ultimately, the data collected during the OU3 RI is intended to help EPA decide if and what response actions are needed to protect human and/or ecological receptors from unacceptable risks from asbestos and any other mining-related contaminants in surface water and sediment in OU3.

4.3.3 Identify the Types of Data Needed

The available strategies and elements that can be used in the ecological risk assessment are discussed as part of the Problem Formulation Document (USEPA, 2008c). The Phase IIC SAP represents implementation of a subset of elements of the presented strategies. Additional elements may be implemented as described in additional SAPs as they are deemed useful.

Several types of information are needed to support a decision regarding remedial actions based on ecological risks for the primary pathways of concern. Data needed for the ecological risk assessment at OU3 (from the Phase II C SAP) can be divided into three basic categories:

- Site-specific toxicity tests
- Observations of population and community demographics
- In-situ measures of exposure and effects

Site-Specific Toxicity Tests

For ecological receptors, direct measurements of effects on exposed receptors to site media are used to assess risks especially for contaminants for which reliable toxicity values are not available to use in the HQ approach for evaluating measured concentration values. In site-specific toxicity tests, ecological receptors are exposed to site media of known concentrations in order to observe whether the media causes adverse effects on growth, survival, and/or reproduction in laboratory test species. At OU3, site-specific toxicity testing will be completed with site surface waters and sediments. Data from the toxicity test results will be used to establish a reliable site-specific exposure response curve. Using this relationship, it may be possible to identify reference concentrations of contaminants in water or sediment that represent the boundary between acceptable and unacceptable effects on fish and benthic invertebrates. If so, then these reference concentrations may be used in the evaluation of other site waters and sediments that have not been tested using aquatic receptors.

Surface water toxicity testing was addressed in the Phase IIA Sampling and Analyses Plan (SAP) as this medium was time-critical. Sediment toxicity testing is addressed in this Phase IIC SAP.

Population and Community Demographics

Measurements of population and community demographics are made in the field to identify if any receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) or composition of species is different than expected. Other demographics include age structure and the absence or presence of pollution tolerant species. Population and community demographic information will be collected for benthic invertebrates, fish and small mammals within OU3. These data will be compared to appropriate matched reference areas.

In-Situ Measures of Exposure and Effects

Measurements of *in-situ* exposure and effects are made on receptors collected from the field, seeking to identify if individuals have higher exposure (tissue) levels, observed lesions and/or deformities that are higher than expected. Asbestos tissue burden levels in selected tissues and the number and severity of gross and microscopic lesions will be measured and compared to matched reference areas. In-Situ measures of exposures and effects will be examined in mammals and birds.

4.3.4 Define the Bounds of the Study

Spatial Bounds

The primary focus of Part C of the Phase II investigation is the Rainy Creek watershed (including upper and lower Rainy Creek, Fleetwood Creek, and Carney Creek, as well as ponds and impoundments on these streams) and the mining site area. Part C will include an evaluation of small mammal and bird populations within the OU3 area (Figure 2-1).

The spatial bounds of the assessment will also include reference areas identified for comparison of mammal and bird populations and benthic invertebrates.

Temporal Bounds

The contamination of sediments and soils is not expected to vary by time.

Receptor Groups and Exposure Pathways

This Phase IIC SAP is focused on a subset of the possible exposure pathways identified for ecological receptors to asbestos and non-asbestos contamination at Libby OU3. The receptor groups and exposure pathways to be addressed include exposure of benthic invertebrates to contaminants in sediments, exposure of fish to contaminants in surface water and sediments, exposure of mammals and birds to contaminants in all media. Other receptor groups and exposure pathways may be addressed in other SAPs.

4.3.5 Define the Decision Rule

In the baseline ecological risk assessment, risks to ecological receptors from a particular chemical in a particular medium will be evaluated using a weight-of-evidence approach, combining the results from up to four possible lines of evidence:

- Calculation of Hazard Quotient (HQ) values based on measured concentration values and available toxicity reference values (TRVs)
- Exposure of test organisms to environmental media samples(surface water and/or sediment) collected from the site to evaluate the magnitude and frequency of any effects on growth, reproduction or survival
- Direct surveys of receptor population and community demographics in comparison to appropriate reference areas
- Direct measurement of receptor exposure and effects in comparison to appropriate reference areas

The weight-of-evidence conclusions will take many factors into account, including the strengths and weaknesses of each line of evidence, and the degree of agreement between the different lines. Thus, no statistical or quantitative decision rule can be stated *a priori*. The following qualitative guidelines will be applied when interpreting risks to each ecological receptor of concern:

- If all lines of evidence agree there is <u>not</u> a risk. If the calculated HQ does not exceed 1 for acute or chronic toxicity, there are no significant growth, mortality or reproduction effects observed in site-specific toxicity tests (compared to reference and laboratory controls), there are no ecologically relevant differences observed in direct surveys of population and community demographics (compared to reference(s)) and there are no ecologically relevant differences observed in direct measurements of exposure and effects (compared to reference(s)), then remedial actions to protect ecological receptors are not likely to be necessary.

- If all lines of evidence agree there is a risk. If the calculated HQ exceeds 1 for acute or chronic toxicity, there is evidence of site-specific toxicity, there is evidence of an adverse impact to population and community structure and function, and there is evidence of in-situ exposure and effects, then remedial actions to protect ecological receptors are likely to be necessary.

- If the results from each line of evidence are mixed (e.g., HQs exceed 1 but direct toxicity is not observed), weight will be placed on site-specific toxicity tests, population and community demographic observations and *in-situ* measures of exposures and effects in proportion to confidence in the measures. The weight assigned to the predictive (HQ) approach will be in proportion to confidence in the exposure estimates and in the toxicity reference value (TRV) used to derive the HQ values.

- If the available lines of evidence are limited (two or three out of four possible), the weight assigned will be in proportion to the confidence in the data for each line of evidence. The ecological decision rule will likely take the form that, if the weight-of-evidence indicates that adverse effects on ecological receptors are occurring, and that these effects are likely to result in a meaningful decrease in the growth, reproduction or survival of local populations compared to what would be expected in the absence of site-related contamination, then a response action will be appropriate.

- It the lines of evidence are very limited, weak or absent and it is not possible to assess possible effects on growth, reproduction or survival, then the decision rule will be more general. For example, it is expected that only one line of evidence (histopathology) will be available for mammals and birds exposed to asbestos with some limited information on population demographics. In this case, the Phase II C data will be used to identify if effects are apparent. If no effects are apparent then further studies may not be necessary.

If effects are apparent and the severity warrants further evaluation then additional studies will be considered to gather additional lines of evidence.

4.3.6 Define the Acceptable Limits on Decision Errors

Two types of decision errors are possible when making risk management decisions:

- A false negative decision error occurs when it is decided that risk is acceptable when the true risk is actually above the level of concern
- A false positive decision error occurs when it is decided that risk is not acceptable when the true risk is actually below the level of concern

Of these two types of errors, EPA is primarily concerned with avoiding false negative errors, since an error of this type can leave human or ecological receptors exposed to unacceptable levels of contamination and risk. The EPA usually identifies 5% as the maximum acceptable probability of making a false negative decision.

A false positive decision error does not leave ecological receptors at risk, but is also of concern to EPA because this type of error may result in the expenditure of resources (time, money) that might be better invested elsewhere. For the OU3 RI and risk assessment process, the goal is as follows: if the true level of risk is less than ½ the acceptable risk level, then there should be no more than a 20% chance that the risk will be declared to be unacceptable.

4.3.7 Optimize the Design

Risks to ecological receptors, including fish, benthic invertebrates, small mammals and birds will be based on a weight of evidence evaluation. Consequently, it is not possible to develop statistical rules that limit the likelihood of false positive or false negative decision errors. Rather, the degree of confidence in the decision is based on the quality of the data available, and the degree to which different lines of evidence yield consistent conclusions. If multiple lines of evidence support the same conclusion, then confidence in the decision is increased. Conversely, if different lines of evidence yield inconsistent conclusions, then confidence in the decision is decreased.

HQ Approach

It is common to begin by an assessment of risks using the HQ approach. Note, however, that this requires the availability of suitable toxicity reference values (TRVs) for the contaminants of concern. Such TRVs do exist for most non-asbestos analytes, and the HQ approach will be used as the first line of evidence for this group of contaminants. If the HQ results suggest that risks are below a level of concern, then no further evaluation will be needed. If the HQ approach suggests that risks may be occurring, then other lines of evidence will be investigated.

In the case of asbestos, no TRV values are currently available for any ecological receptor group. Even if such values were available, their relevance to OU3 would be uncertain because the toxicity of asbestos may depend on the mineral type (LA) and on the particle size distribution in site waters. For this reason, the first line of evidence evaluated will be site specific toxicity testing. This may provide direct data on the toxicity of site sediments to an appropriate benthic species. Assuming that the site sediment samples produce toxicity, then a site-specific TRV can be developed by analyzing the testing results. The resultant site-specific TRV may then be used to predict, using the HQ approach, the expected toxicity of LA in other site sediments that have not been tested. A similar approach was used to evaluate the toxicity of LA in surface water as part of the Phase IIC SAP.

Optimize the Sampling Design for Site-Specific Toxicity Testing

The objective of site-specific toxicity testing with sediments is to develop a site-specific exposure-response curve for toxicity to benthic invertebrates. This is best achieved by testing sediments at regularly-spaced concentration intervals ranging from low to high. Site-specific toxicity testing with LA in surface water was addressed in the Phase IIA SAP.

The sediment results for LA from Phase I can be stratified into the following bins (seep samples on Carney Creek not included) based on the amount of asbestos:

PLM-VE Result	Range of Mass Percent	Sampling Station
Bin A (ND)	None detected (likely < 0.05%)	URC-1, FC-1
Bin B1 (Trace)	LA detected, > 0% but < 0.2%	FC-2
Bin B2 (<1%)	LA detected, >0.2% but < 1%	URC-2 , TP, MP, LRC-1, LRC-2, LRC-4, LRC-5, LRC-6, FC-Pond, CC-2
2%	LA detected >1%	LRC-3, TP-TOE1
3%	LA detected >1%	TP-TOE2
4%	LA detected >1%	CC-1

It appears that the highest concentrations of LA were found at the toe of the tailings pond, Lower Rainy Creek (at LRC-3) and upper Carney Creek (CC-1). For surface waters, the highest concentrations of LA tended to occur in the ponds and impoundments, and also in the influent waters to those ponds (USEPA, 2008b).

Based on a review of the Phase 1 data (USEPA, 2008c) a few metals had maximum concentrations above probable effect concentration screening benchmarks (Section 3.2) including chromium, manganese and nickel. The most notable of these was chromium with concentrations ranging up to 988 ppm (at CSS-8). The concentrations of these metals at each sampling location are shown in Figure 3-4.

Chromium was detected at greater than 200 ppm at two locations (seep samples excluded) where asbestos was detected at >1% (TP-TOE2 and LRC-3). There was only one sampling location (FC-Pond) where chromium was detected at >200 ppm with low concentrations (> 0.2% but <1%) of asbestos and two sampling locations (TP-TOE1 and CC-1) where high asbestos was measured with lower chromium (< 50 ppm).

The sampling locations for sediment toxicity testing were selected using the following general rationale:

- Test a range of asbestos measurements with two samples collected within each of the asbestos sample result bins (see prior table in Section 3.2)
- Test sediments with low asbestos and high chromium
- Test sediments with high asbestos and low chromium
- Test sediments at lower Rainy Creek sampling locations where data is also being collected on the benthic invertebrate community and fish community to be support a weight-of-evidence risk evaluation

An initial set of sediment samples were selected for testing based on Phase I data to reflect a range of asbestos and non-asbestos contaminants (primarily a subset of metals based on an initial screening in Section 3.2). These sampling locations will be re-evaluated once sediment asbestos analyses results are available from the first part of the Phase II A SAP.

To optimize the study design, the following stations were selected for the collection of sediment samples for toxicity testing to:

- Non Detect to Trace Amounts of Asbestos (URC-2 and FC-2)
- Lower Amounts of Asbestos (> 0.2% and < 1%) (LRC-1; and FC-Pond)
- Low Asbestos (> 0.2% and < 1%) and high chromium (>200 ppm) (FC-Pond)
- 2% Asbestos (LRC-3)
- 4% Asbestos and low chromium (<50 ppm) (CC-1)
- Reference (Ref-1)

The following station was selected to provide a line of evidence for a weight-of-evidence approach to assess risks for benthic invertebrates in lower Rainy Creek:

- LRC-5

Optimize the Sampling Design for Population and Community Demographics

Population and community demographic information will be collected for benthic invertebrates, fish, small mammals and birds and compared to those collected in reference areas. The objective is to identify if any receptor population has unusual numbers of individuals (either lower or higher than expected), or whether the diversity (number of different species) of a particular category of receptors (e.g., benthic organisms, fish, mammals) is different than expected.

For benthic invertebrates, the benthic community will be sampled at locations along Fleetwood Creek, Carney Creek, and Rainy Creek that are concurrent with the Phase I and Phase IIA surface water and sediment sampling locations. This will optimize the ability to interpret community metrics versus contaminant concentration. The objective is to identify if metrics are different in comparison with reference areas and if any observed changes could result from contaminant exposures. The reference area(s) will be identified to match as closely as possible the habitat variables present at the aquatic sites being evaluated. Note that, because asbestos contamination may have been transported by air from the mine site area to upstream locations along Rainy Creek, upstream locations may not be an appropriate reference. The methods for benthic invertebrate collections will include those that have been used by the United States Forest Service in the Kootenaii National Forest. This will optimize comparison of data collected at OU3 with those collected in other streams in the National Forest over a several year period.

For fish, surveys will be performed at selected locations within the Rainy Creek drainage that are concurrent with the Phase I and Phase IIA surface water and sediment sampling locations. As with the benthic invertebrate sampling, fish will be collected at stations that are concurrent with surface water and sediment sampling locations. Fish species and number (density) are noted and compared to matched reference locations.

Optimize the Sampling Design for In Situ Measurements of Exposure and Effects

In-situ measurements of exposure and effects will be examined in mammals and birds collected from the following areas:

- Disturbed area on the mine site where asbestos levels in soils are highest
- In a forested area near the mine disturbed area where asbestos levels are lower in soils compared to than the mine site proper and more habitat is available.
- In a riparian area near the Tailings Impoundment
- In a reference area upwind of OU3 in a similar forested habitat type.

A reference area will be selected that is matched as closely as possible to the forested area within OU3. The objective of the *in-situ* measurements is to identify if asbestos tissue burdens, the frequency and severity of gross pathology and/or histopathological lesions in selected tissues are greater than reference areas.

This page intentionally left blank to facilitate double-sided printing.

5.0 SAMPLING PROGRAM DESIGN

Table 5-1 provides an overview of the data collection activities that will be performed under Phase IIC of the OU3 RI. The following sections provide descriptions of the general experimental design for each of the Phase IIC elements. Specific details with regard to sampling method requirements, laboratory testing requirements and analytical methods are provided in subsequent sections.

5.1 Site-Specific Sediment Toxicity Testing Methods and Procedures

One of the most direct methods for evaluating toxicity of site media such as surface water and sediment to ecological receptors is through site-specific toxicity testing. In this approach, test organisms are exposed to site media in the laboratory to determine if the site media causes adverse effects on survival, growth and/or reproduction. Figure 5-1 provides a conceptual flow diagram for sediment toxicity testing. As shown, the approach is similar to that used for surface water in the Phase IIA SAP (USEPA, 2008b) (Figure 5-2), except that a dilution series is not needed because sediments will be collected from a range of locations that span a wide range of both asbestos and metal concentrations. Sediments will be collected from eight locations in the Rainy Creek Watershed including two in Fleetwood Creek (FC-Pond, FC-2), one on Carney Creek (CC-1), one on Upper Rainy Creek (URC-2), three on lower Rainy Creek (LRC-1, LRC-3, and LRC-5) and one from a reference area (Ref-1) (Table 5-2). As described previously, the locations were selected to test the range of observed asbestos concentrations with the goal of identifying a toxicity value for sediments that is protective of benthic organisms. In addition to the samples within OU3, samples will also be collected for testing from a reference area.

Sediments will be collected as a composite of grab samples. Two laboratory test organisms will be exposed (the amphipod *Hyalella azteca* and midge *Chironomus tentans*) to the sediment samples in the laboratory and survival, growth and reproduction examined over a 42-d period. All sediment samples will be analyzed for asbestos and TAL metals. The Phase IIA sediment sampling and analyses results will be examined to identify any additional analyses are necessary.

5.2 Population and Community Demographic Observations

5.2.1 Benthic Invertebrates

Benthic invertebrates will be collected at 13 stream locations (Table 5-2) including two in upper Rainy Creek (URC-1A and URC-2), six in lower Rainy Creek (LRC-1 to LRC-6), two in Fleetwood Creek (FC-1 and FC-2), two in Carney Creek (CC-1 and CC-2) and one at a reference location (Ref-1). Benthic invertebrate samples would be collected at the same locations as sediment and surface water samples to facilitate an analysis of the correlation between community status and contaminant level. Samples would be collected according to an established EPA *Rapid Bioassessment Protocol* (RBP) (USEPA, 2003). Benthic invertebrates will be collected at each sampling station in the same manner as that conducted by the US Forest Service. For each sampling location, a number of alternative metrics of benthic community status will be calculated and combined to yield a Biological Condition Score. A number of alternative measures of habitat quality will also be measured to yield a Habitat Quality Score (a comparison of the Biological Condition Score to the Habitat Quality Score provides information on the likely contribution of non-habitat factors (e.g., chemical pollution) on the benthic community). The scores and individual metrics will be examined to identify if the community is impacted relative to reference and if there are any apparent trends in condition with asbestos concentrations. This method does require the selection of at least one appropriate reference area for comparison. The reference area will be selected to match as closely as possible the habitat variables present at the aquatic sites being evaluated. Note that, because asbestos contamination may have been transported by air from the mine site area to upstream locations along Rainy Creek, upstream locations are not an appropriate reference.

5.2.2 Fish

Fish will be collected at the same sampling locations identified for collection of benthic invertebrates as well as some additional locations. In addition to the benthic invertebrate locations, fish will also be collected from the Mill Pond, Tailings Pond and Fleetwood Creek Pond (Table 5-2). For each sampling location the following information will be recorded:

- The species identified
- The number of individual fish
- The size class structure of the fish collected by weight and length
- The ratio of males to females
- The frequency of any identified external abnormalities.

These results will be compared to those collected from the reference area.

5.2.3 Mammals and Birds

Quantitative surveys of mammalian and avian density and diversity are difficult to perform because of the high natural variability in receptor density over space and time. For this reason, formal population surveys will not be attempted at this time. However, semi-quantitative data in the form of number of organisms of each species collected per trapping day will be available from the field collection effort for the measurement of In-situ exposure and effects (Section 5.3) from both on-site locations and reference locations. Comparison of these trapping rates will provide an initial impression as to whether population densities are likely to be similar or dissimilar in site areas compared to reference areas. If evidence of an apparent difference is obtained, this may be followed with more quantitative efforts to compare population demographics, depending on the overall weight of evidence available.

5.3 In-Situ Measures of Exposure and Effects

In this line of evidence, mammals and birds will be collected from site locations (on-site, forest area, riparian area, surface water bodies) and examined for gross and microscopic pathological effects. The incidence and severity of effects observed will be compared to organisms from suitable reference areas, and are also will be analyzed for possible correlations with the relative concentrations of LA in tissues and the collection area. These data will help define the spatial extent of LA contamination that can impact wildlife. Interpretation of the ecological consequences of any gross or histological lesions that are observed will be based on literature information that associates the pathology effects with adverse effects on growth, reproduction, and survival, as well as on consultation with experts in the field. In-Situ measures of exposure and effect are discussed for receptor groups in the following subsections.

5.3.1 Fish

A subset of the fish sampled for population and community demographics from the site and reference areas will be collected to assess the level of exposure via measures of asbestos body burden, and the level of effect via the frequency and severity of histological lesions. The subset of sample locations include one in upper Rainy Creek (URC-2), three in Rainy Creek (LRC-1, LRC-3 and LRC-5), one in Fleetwood Creek (FC-1), one in the Tailings Pond (TP-1), and one at a reference location (Ref-1). This is implemented simply by selecting fish that are captured for the fish community survey (Section 5.2.2), and collecting and preserving tissues from these fish for potential future analysis.

The Phase IIA SAP (USEPA, 2008c) specifies toxicity testing with LA in the laboratory with rainbow trout. These exposed fish will be examined for histopathology.

Gross and Microscopic Lesions

For a subset of the fish collected during the population survey, a gross necropsy will be performed to identify any gross external or internal lesions. After the necropsy, specific target tissues will be removed and preserved for possible future histopathology examination. Lesions that have been reported in the literature following exposure of aquatic organisms to asbestos are summarized in Table 5-3. Based on this data, the target tissues for histopathology examination include the lateral line, gill, kidney and gastrointestinal tract.

At seven of the sixteen sampling locations identified for fish community surveys (Table5-2), ten fish representing at least two different species will be examined for gross necropsy and target tissue collection. This subset of sampling locations represents a range of asbestos exposure concentrations in surface water and sediment. The target tissue samples will be preserved and held for possible future analyses.

If these samples are examined and the approach is implemented, the incidence and severity of effects observed in fish from on-site locations would be compared to that observed in organisms collected from an appropriate reference area, and also to the concentrations of asbestos in surface water and sediment at the sampling stations in an effort to establish a dose-response relationship. Consequences of the measured pathology effects will be evaluated based on literature information that associates the pathology effects with adverse effects on growth reproduction and survival as well as the results of the laboratory testing completed as part of the Phase IIA SAP.

Tissue Burden

If the histopathology samples are examined then measurements of LA tissue burden in the collected tissues (lateral line, gill, kidney and gastrointestinal tract) will also be performed. Tissue to be analyzed will be weighed (wet weight) and then dried and ashed. The ashed residue will be resuspended in acid and water and an aliquot deposited on a filter for analysis by TEM. Results would be expressed as fibers of LA per gram (wet weight) of tissue. The tissue samples to be analyzed would be split samples of those collected and preserved for histopathology. The tissue samples to be analyzed will be split samples of those collected and preserved for histopathology. Samples will be submitted for asbestos analysis using transmission electron microscopy (TEM) in accord with the International Organization for Standardization (ISO) 10312 method (ISO, 1995).

5.3.2 Small Mammals

At present, one of the few lines of evidence available to evaluate risks to wildlife from asbestos is the *in-situ* measurement of exposure and effect in organisms collected from the site. This technique (Figure 5-3) has the advantage that it allows measurement of exposure and effects by both oral and inhalation exposures, and may allow development of maps that indicated the relative levels of exposure as a function of location. The chief disadvantage of this method is that the *in-situ* measures of exposure and effect may not be easy to extrapolate to effects on growth, reproduction and survival, and hence on population stability.

Sampling Locations (Trap Areas)

Four areas are identified for small mammal trapping. These locations are listed in the following table along with the rationale for their selection. The exact locations of the sampling areas and placement of trap lines will be made during the initial field reconnaissance based on the identified habitats, terrain, access and other considerations.

Location ID	General Descriptions and Rationale	General Identified Areas
SMT-1	On the Mine Site Disturbed Area. This area is expected to have highest the highest asbestos exposures but not the best habitat to support species.	MW-6 or MW-16
SMT-2	Near the disturbed Mine Site Area in an area with better	Near SL-45-01

Location ID	General Descriptions and Rationale	General Identified Areas
	habitat than SMT-1 with known asbestos contamination in soils, tree bark and duff.	
SMT-3	Riparian area near water body with both established use by waterfowl and/or shorebirds and known asbestos contamination in sediments and/or surface water.	Tailings Pond
SMT-Ref	Reference area with habitat matched closely in terms of vegetative cover and elevation to SMT-2.	Area upwind of OU3 to the west

Trap Method

Methods for capturing mammals and in particular the use of trap arrays are reviewed by Jones et al., 1996. Typical methods of trap placement include transects, grids and webs (Wilson et al., 1996). Pearson and Ruggiero (2003) compared transect versus grid trapping arrangements for sampling small mammal communities in two forest cover types in west central Montana. They found that transect arrangements compared to grid arrangements yield more total captures, more individual captures and more species than grid arrangements in both cover types in both of the years examined. Differences between the two methods were greatest when small mammals were least abundant. Based on this reported efficiency and the lower level of effort required for the line transect method compared to the grid method, the line transect trap method will be used to collect small mammals at Libby OU3.

In the line transect method; traps are placed at equal intervals along a line which is located randomly within a habitat type. More than one line may be located within a habitat type (sampling location). Traps should be placed at habitat features (e.g., log, tree, runway, burrow) as long as they lie within 2 meters of the point. Wilson et al. (1996) recommends placing two traps at each trap point to avoid the saturation of traps with “trap-happy” individuals that are readily captured. The practice increases the chances that animals that are less active or less attracted to traps to be caught.

Target Species

In order to implement this approach, it is first necessary to identify the classes of small mammals that are likely to be maximally exposed. The most important selection criteria include the following:

- Non-transitory. Some organisms migrate over long distances, and are present in the area of the site for only a short time each year. Because of the brief interval they would be exposed, such organisms would have less exposure than organisms that are present year round or for most of the breeding season.

- Small home range. Organisms that have a large home range are likely to spend a small part of their time in and about the most heavily impacted areas of the site. Consequently, they are likely to be less exposed than organisms that have a small home range and spend a high fraction of their time in and about the impacted areas.

In addition to these two baseline factors, there are a number of other factors that may also influence the relative level of exposure, including the following:

- Foraging strategy – Species that forage on the ground and have a greater potential to disturb asbestos fibers are expected to have more inhalation exposure than those that forage in shrubs or tree foliage. Species that feed on insects in the air and carnivores that prey on other mammals and birds are expected to be less exposed.
- Habitats and Nesting – Where species find shelter, give birth (or nest) and/or rear young may also influence exposures. Many species burrow into the ground or create shallow runs under forest litter. Some others will create nests/dens in existing cavities of barren rock or dead trees. Burrowers are expected to receive higher exposures compared to those species that live higher in trees.

- Body Size – Ingestion rates and breathing rates per unit body weight tend to be higher for species with small body weights compared to species with higher body weights. Thus, exposure by both oral and ingestion pathways may be highest for small receptors.

- Longevity In humans, it is well established that risk of adverse effects is a function of cumulative exposure. That is, risk depends both on exposure level and also on exposure duration. For this reason, organisms that have longer life spans will tend to have higher cumulative exposures and hence may be more likely to display adverse effects from asbestos exposure.

Taking these factors into account, the feeding guilds and species identified as residing within the area of Libby OU3 (listed in Attachment A of USEPA 2008c) were evaluated in order to identify a list of receptors most likely to have high exposures to LA, as follows:

1) Species inhabiting terrestrial and riparian habitats were segregated into two groups based on habitat type (terrestrial and riparian).
2) Because exposures to asbestos for species inhabiting riparian habitats are expected to be primarily related to ingestion of aquatic food items as well as surface water and sediments, the riparian species were segregated into two exposure groups by feeding guild. These include aquatic invertivores/omnivores and piscivores.
3) For species that inhabit terrestrial habitats, those that forage on the ground and or inhabit nests or burrows were identified from the larger list and classified into a “ground” foraging group. These species are expected to be the highest exposed to asbestos via inhalation and ingestion as a result of probing and disturbing asbestos in soils and ground litter.
4) Species that forage primarily in trees and shrubs were identified from the larger list and classified as an “arboreal” foraging group. These species may be exposed to asbestos on tree bark or leaf surfaces as result of foraging for food.

5) Carnivorous species were identified and placed in separate group based on feeding guild. These species are expected to be exposed to asbestos primarily via ingestion and inhalation exposures are expected to be lower than those species that forage on the ground for food.
6) The ground and arboreal groups were further stratified into feeding guilds (invertivore, grainivore, omnivore, carnivore) to reflect exposures related to ingestion.
7) The species in each group were then reviewed further and those with small home ranges and small body sizes were selected preferentially. These species are expected to be maximally exposed to asbestos impacted area and will not range in and out of the area.
8) Species that are transients (occurring at the site only during spring or fall migrations) were excluded, while sthat are resident year round or are present for extended periods during the warm weather were retained.

The following table summarizes the categories of receptor groups that are likely to be maximally exposed in each exposure area.

Location	**Exposed Receptor Group**	**Exposure**
Mined area and Forest area	Ground Invertivore	Ingestion of asbestos in soil invertebrates and inhalation of asbestos in soil during disturbance.
	Ground Herbivore/Omnivore	Ingestion of asbestos in/on plant material and inhalation of asbestos in soil during disturbance.
Riparian area	Aquatic Invertivore/Omnivore	Ingestion of asbestos in aquatic plants, aquatic invertebrates and/or sediments.

The targeted mammalian species for collection in the mined area and forested area are the ground foraging species (invertivore, herbivore, omnivore). The targeted species in the riparian area are aquatic invertivores and omnivores. Any protected species captured will be released. Table 5-4 provides the list of ground invertivores, ground herbivores and omnivores and aquatic invertivore and omnivores that may be in the OU3 area.

In nine west-central Montana forest stands (five dominated by old-growth ponderosa pine (*Pinus ponderosa*) and four by western larch (*Larix occidentalis*) over 22, 752 trap nights, the most commonly collected species were deer mice (*Peromyscus maniuclatus*), southern red-backed voles (*Clethrionomys gapperi*), and red-tailed chipmunks (*Tamias ruficaudus*) (Pearson and Ruggiero, 2003). Yellowpine chipmunk (*Tamias amoenus*), golden-mantled ground squirrel (*Spermophilus lateralis*), vagrant shrew (*Sorex vagrans*), dusky or montane shrew (*Sorex monticolus*), snowshoe hare (*Lepus americanus*) and red squirrel (*Tamiasciurus hudsonicus*) were also collected but less frequently (Pearson and Ruggiero, 2003). This information agrees with the reported frequency of sightings of ground dwelling small mammalian species as reported in the Montana Tracker (numbers listed in Table 5-4). The most common ground herbivore/omnivore reported in Lincoln county are the deer mouse and the southern red-backed vole which are the two most common species captured in the trapping completed by Pearson and Ruggiero (2003). This agreement provides an indication of what species to expect to be trapped using line transect trapping and Sherman traps at Libby OU3.

Trap Type

While many types of traps are available for the collection of small mammals, the small mammal collection at Libby OU3 will use Sherman Live traps. Sherman Live traps are a type of box trap that are the most effective for capturing small terrestrial mammals unharmed (Wilson, 1996). This trap is rectangular in shape with a spring-loaded door that becomes triggered once an animal enters the trap. Box traps are recommended over simple snap traps (or kill traps) due to reduced occurrences of predation and trap disturbance by raccoons and deer. Snap traps are lightweight and easily triggered or moved by non-target species. In addition, once an animal is captured in a snap trap, it becomes a likely target for predation. The heavier box trap, with solid sides, is better suited to withstand disruption by predation. Live trapping is also preferred for the collection of samples for histopathology examination. Animals collected from kill traps may decompose prior to collection making tissue examination impossible.

Trapping Effort

Trapping effort is the product of the number of traps used and the time over which those traps are monitored. The number of traps multiplied by the number of “trap-nights” gives the number of “trap-nights” for a particular study. Wilson et al. (1996) recommends a minimum of 500 trap nights for a preliminary investigation of a habitat. Data from studies with similar trapping effort can be compared using relatively simple models the include capture indices and abundance indices.

Wilson et al. (1996) recommends a trap transect be at least 150 m long with traps placed every 10 to 15 m. A general rule is to space traps at a distance no greater than the radius of a circle having an area equal to that of the average home range (if known) of the target species. The deer mouse is the most likely organism to be collected based on the data evaluated in the Problem Formulation (USEPA, 2008b). This species has a reported home range averaging 1 hectare or less and may range from a few hundred to a few thousand sq m (http://www.natureserve.org/). Based on this information of trap spacing of 10 meters is more than adequate for a 200 square meter home range.

The targeted trapping effort at Libby OU3 will be 510 trap nights for the Phase IIC SAP. Three 170 m line transects will be established at each of the sampling locations and traps placed (2 each) at 10 m intervals and collected over a five day period of time. This design will result in a 510 trap night effort per sampling location. The trapping effort (time) required to complete a species inventory can be determined with a species accumulation curve, a plot of cumulative number of species captured versus cumulative trapping effort. When the curve reaches a plateau, or when the capture of species or individuals no longer increases with additional effort, the trapping effort may be adequate. If this plateau is reached prior to the 5 day trapping period and the targets for collection of individual animals and species for tissue collection is met, then the trapping effort may cease earlier.

Measurements

For each of the mammals collected, the species, weight and any notes of physical abnormalities will be recorded. If possible age will also be recorded. This information will be used to calculate statistics on abundance and species diversity. The results for the OU3 sample areas (SMT-1, -2 and -3) will be compared to the reference area (SMT-Ref).

A subset of the mammals collected will be sacrificed for the examination of gross and microscopic lesions in the lungs, gastrointestinal tract, and kidney. These mammals will be aged. The following targets are identified for histopathology examination:

- For each sampling location (SMT-1, -2, -3, SMT-Ref) at least 15 individuals within the ground herbivore/omnivore group will be examined
- Any shrews captured will be examined (ground invertivore exposed receptor group or aquatic invertivore/omnivore receptor group) at up to 10 individuals per sampling location)
- Similar species (within the ground herbivore/omnivore) group will be examined across sampling locations at SMT-1, -2 and SMT-ref with a goal of at least three species
- For riparian species the goal is two species
- Any arboreal invertivore collected will be examined (up to 10 individuals per sampling location)

Based on available information as previously discussed the most common species expected in the collections are the deer mouse and southern red-backed vole which are within the ground herbivore/omnivore receptor group. Pearson and Ruggiero (2003) did have some success capturing shrews using the Sherman traps with the vagrant shrew and dusky shrew being the sixth and seventh most frequently captured mammal. Shrew capture at OU3 is possible.

Initial Field Reconnaissance

Prior to the small mammal trapping, an initial field reconnaissance will be completed to confirm the exact sample locations for the collection effort. This reconnaissance will also allow for arrangement of the logistics necessary for the mammal and bird collections and the initial placement of traps "opened". This is part of the small mammal sampling procedure where traps are placed 6 days prior to the start of collections to accustom the animals in the field to their presence.

Gross and Microscopic Lesions

A large number of studies have been performed in mammals to identify the effects of inhalation exposure to asbestos on the respiratory tract, and, to a lesser degree, the effects of inhalation and ingestion exposure on other organs (e.g. gastrointestinal tract). In animals, histological signs of tissue injury can be detected at the site of deposited fibers within a few days (ATSDR, 2001).

Ingestion exposures have been associated with lesions in the parathyroid tissue, brain tissue, pituitary tissue, endothelial tissue, kidney tissue, and peritoneum tissue (Cunningham et al., 1977). Induction of aberrant crypt foci in the colon (Corpet et al., 1983) and tumors of the gastrointestinal tract have also been reported. Inhalation exposures are associated with fibrosis, lung tumors and lesions along the respiratory bronchioles, alveolar ducts, alveoli, and lung tissue (McGavran et al. 1989; Donaldson et al. 1988; Davis et al., 1980a, 1980b, 1985, 1986). Mesotheliomas have been observed (Davis and Jones 1988, Davis et al. 1985, Wagner et al. 1974, 1980, Webster et al. 1993). Based on this information the target tissues for histopathology examination in mammals include the lungs, gastrointestinal tract, and kidney.

Mammals collected from each of the sampling areas and sacrificed for examination will be examined for gross pathology and microscopic pathological effects in the target tissues (lungs, gastrointestinal tract and kidney). The incidence and severity of effects observed will be compared to those from the reference area, and will also be correlated with the relative concentrations of LA in duff in the collection area. These data, combined with the tissue burden data, will help define the spatial extent of LA contamination that can impact wildlife. Interpretation of the ecological consequences of any gross or histological lesions that are observed will be based on literature information that associates the pathology effects with adverse effects on growth, reproduction, and survival, as well as on possible consultation with experts in the field.

<u>Tissue Burden</u>

Selected organs (lungs, gastrointestinal tract and kidney) of mammals collected at the site will be analyzed for asbestos tissue burden. Tissue burden in lung will be interpreted as an indication of inhalation exposure, and tissue burden in the gastrointestinal tract and kidneys will be taken as an indication of oral exposure. Comparison of the tissue burdens from OU3 sample locations and the reference location will be used to establish an estimate of the spatial extent of LA exposures recognized as being higher than background.

LA tissue burden in the collected tissues (lungs, gastrointestinal tract and kidney) will be determined. Tissue to be analyzed will be weighed (wet weight) and then dried and ashed. The ashed residue will be resuspended in acid and water and an aliquot deposited on a filter for analysis by TEM. Results would be expressed as fibers of LA per gram (wet weight) of tissue.

<u>Samples of Duff for Asbestos Content</u>

Samples of duff will be collected at a sub-sample of the trap locations along each sampling transect for the analyses of asbestos content. These samples will be spaced 30 m apart along each of the three small mammal sampling transects within each general sampling location. This effort across the four sampling locations will total 60 samples. The information will be used to investigate if any correlation exists between the asbestos content observed in duff and the extent and/or severity of histopathological lesions observed in any of the target tissues. As described in prior sampling efforts and the Problem Formulation for Ecological Risk Assessment (USEPA, 2008c), the analyses of asbestos in duff (an organic sample) is more quantitative and informative compared to analyses of asbestos in forest soils. Therefore, the sampling of forest soils is not recommended as part of the Phase IIC investigation.

5.3.3 Birds

At present, one of the few lines of evidence available to evaluate risks to wildlife from asbestos is the *in-situ* measurement of exposure and effect in organisms collected from the site. This technique (Figure 5-3) has the advantage that it allows measurement of exposure and effects by both oral and inhalation exposures, and may allow development of maps that indicated the relative levels of exposure as a function of location. The chief disadvantage of this method is that the *in-situ* measures of exposure and effect are not easy to extrapolate to effects on growth, reproduction and survival, and hence on population stability.

Sampling Locations

Four areas are identified for avian sampling. These are the same general locations identified for small mammal collection. The exact locations of the sampling areas and placement of trap lines will be made during the initial field reconnaissance based on the identified habitats, terrain, access and other considerations.

Collection Method

The use of mist nets for monitoring bird populations is reviewed by Ralph and Dunn (2004). Mist netting is often used to identify what species are present within a collection area but can be more biased and less efficient compared to census methods (visual and/or auditory surveys). The method collects more ground-foraging and non-singing birds compared to auditory and visual surveys and misses some species such as aerial insectivores and raptors. The method, however, is not affected by the observer's skills at recognizing birds visually and/or their auditory calls and unlike other census methods, allows for the physical collection of birds for further examination (histopathology and tissue residues of contaminants). Based on the attributes of the method, mist netting was selected for use for the collection of birds at Libby OU3.

Targeted Species

The targeted avian species for collection in the mined area and forested area are the ground foraging species (invertivore, herbivore, omnivore). The targeted species in the riparian area are aquatic invertivores and omnivores. Any protected species captured will be released. Table 5-4 provides the list of ground invertivores, ground herbivores and omnivores and aquatic invertivores and omnivores that may be present in the OU3 area. Based on the number of recorded sighting of species within these groups within Lincoln County in the Montana Natural

Heritage Program Animal Tracker (http://fieldguide.mt.gov/), the species are expected to be the most commonly collected include the American robin (*Turdus migratorius*), the Northern flicker (*Colaptes auratus*), Townsend's Solitaire (*Myadestes townsendi*), warbling vireo (*Vireo gilvus*), winter wren (*Troglodytes troglodytes*), chipping sparrow (Sizella passerine), pine siskin (*Carduelis pinus*) and ruffed grouse (*Bonasa umbellus*). For riparian species the most common species include the mallard (*Anas platyrhynchos*) and spotted sandpiper (*Actiis macularius*).

Measurements

The primary goal of the collection of birds is for the examination of asbestos exposures (tissue burdens) and histopathology (the incidence and severity of histopathology lesions). A greater level of effort is required for field sampling intended to collect enough data for quantitative comparisons of species diversity, density and abundance of birds between sampling locations (Ralph and Dunn, 2004). Measurements will however be recorded for the birds collected in nets at each of the sampling locations and general qualitative comparisons will be made between locations. For each bird collected, the species and age (if possible) will be recorded. Birds collected and not sacrificed for further analyses will be released after clipping the specific feathers for marking as being previously collected.

A subset of the birds collected will be sacrificed for the examination of gross and microscopic lesions in the lungs, air sac, gastrointestinal tract, and kidney. The following targets are identified for histopathology examination:

- For each sampling location (SMT-1, -2, -3, SMT-Ref) at least 15 individuals within the ground invertivore and herbivore exposed receptor groups (Table 5-4) will be examined
- Similar ground invertivore and herbivore species will be examined across sampling locations with the goal of at least three species.
- For the riparian area, up to 10 individuals will be examined representing at least two species
- Any arboreal invertivore collected will be examined (up to10 individuals per sampling location)

Based on available information as previously discussed the most common species expected in the collections are the chipping sparrow, pine siskin, American robin, winter wren and northern flicker.

Gross and Microscopic Lesions

The effects of asbestos exposures in avian species are not known. There is only one identified study for asbestos exposure in birds (Peacock and Peacock, 1965) found in the literature. This study exposed White Leghorn chickens to asbestos (unknown origin) in tributyrin by injection into the axillary air sac. Injection exposures are not the same as exposures that may occur to avian species in the field resulting from ingestion and/or inhalation and thus responses may be different. This one study, however, may yield some information on what lesions could be observed in avian species exposed to LA in the field at OU3. The investigators injected asbestos into a small subcutaneous area just below the shoulder joint where it was easy to inject aerosols or fluids into the respiratory system. They attempted to puff asbestos dust into the air sacs but did not find this successful as the fibers adhered to the moist surface of the air sac immediately and did not penetrate far into the lung. Finely ground fibers suspended in tributyrin did travel deeply into the respiratory system and reached the pulmonary alveoli and were recognized histology. When injected into the lumen of the air sac the fibers spread over the surface of mesothelium in the air sacs and penetrated by the recurrent bronchi to the alveoli of the lung. The reactions to the injections were inflammatory. Of the wandering cells only the macrophages appeared to engulf fibers and transport them to neighboring subepithelial lymphoid follicles. The injection exposures resulted in several lung tumors. In some tumors, asbestos fibers were measured four years after exposure.

Birds collected from each of the sampling areas will be examined for gross and microscopic pathological effects in the target tissues (lungs, air sac, gastrointestinal tract and kidney). The incidence and severity of effects observed will be compared to those from the reference area, and will also be correlated with the relative concentrations of LA in duff in the collection area. These data, combined with the tissue burden data, will help define the spatial extent of LA contamination that can impact wildlife. Interpretation of the ecological consequences of any gross or histological lesions that are observed will be based on interpretation of the severity of effect observed as well as possible consultation with experts on avian pathology and toxicology.

Tissue Burden

Selected organs (lungs, air sac, gastrointestinal tract and kidney) of birds collected will be analyzed for asbestos tissue burden. Tissue burden in lung will be interpreted as an indication of inhalation exposure, and tissue burden in the gastrointestinal tract and kidneys will be taken as an indication of oral exposure. Comparison of the tissue burdens from OU3 sample locations and the reference location will be used to establish an estimate of the spatial extent of LA exposures recognized as being higher than background.

LA tissue burden in the collected tissues (lungs, air sac, gastrointestinal tract and kidney) will be determined. Tissue to be analyzed will be weighed (wet weight) and then dried and ashed. The ashed residue will be resuspended in acid and water and an aliquot deposited on a filter for analysis by TEM. Results would be expressed as fibers of LA per gram (wet weight) of tissue. The tissue samples to be analyzed will be split samples of those collected and preserved for histopathology.

Samples of Duff for Asbestos Content

Samples of duff will be collected at a sub-sample of the trap locations along each sampling transects for small mammal collection for the analyses of asbestos content as described as the previous section. Birds will be collected in these same sampling locations, and the results of analyses of asbestos content in duff samples (completed for small mammals) will be used to investigate if any correlation exists between the asbestos content observed in duff and the extent and/or severity of hispathological lesions observed in any of the target tissues.

6.0 SAMPLING METHOD REQUIREMENTS

All sampling of environmental media within OU3 described in this SAP will be performed by personnel who are properly trained in the field collection methods summarized in the OU3 Standard Operating Procedures (SOPs) provided in Attachment B and the Phase IIC experimental sampling design details presented below. The field sampling teams will follow procedures in the Health and Safety Plan (HASP) prepared by MWH for the OU3 investigation.

6.1 Sediment Sampling Methods and Procedures

Sediments will be collected from a total of nine sampling locations and submitted for both sediment toxicity testing (described in Section 7.1) and analyses of asbestos. At each sampling location, sediment will be collected in accord with OU3 SOP No. 5. In brief, a single sediment sample will be collected from each station. Each sample will consist of a grab sample collected from low-energy (i.e., depositional) portions of the stream channel that are inundated by creek water at the time of sampling (i.e., locations of sediment deposition to channel). Each grab sample will be collected using the "direct sampling" method and compositing instructions included in OU3 SOP No. 5. The mass of sediment collected may be estimated by visual assessment of sediment volume.

All sampling and field measurement equipment that is used at more than one sample station must be decontaminated following each use. Appropriate equipment decontamination procedures are provided in OU3 SOP No. 7.

6.2 Benthic Invertebrate Sampling Methods and Procedures

Benthic invertebrate samples will be collected from twelve sampling locations including two in upper Rainy Creek (URC-1 and URC-2), six in lower Rainy Creek (LRC-1 to LRC-6), two in Fleetwood Creek (FC-1 and FC-2) and two in Carney Creek (CC-1 and CC-2). Samples will also be collected from a reference location. Samples will be collected according to the procedures in SOP#BMI-LIBBY-OU3 (Appendix B). As described previously, a number of alternative metrics of benthic community status will be calculated for each sampling station and combined to yield a Biological Condition Score. A number of alternative measures of habitat quality will also be measured to yield a Habitat Quality Score. The scores and individual metrics will be examined to identify if the community is impacted relative to reference and if there are any apparent trends in condition in relation to asbestos concentrations as well as responses observed in the sediment toxicity testing.

The U.S. Forest Service (Vinson, 2007) has collected benthic invertebrates from several locations in the Kootenaii National Forest (Figure 6-1) over a several year period (1998-2006). Benthic invertebrates were collected from riffle habitats using a Surber net with a 250 micron mesh net. Three samples were collected at each site and composted to form s single sample with an area of 0.279 square meters per sample. At Libby OU3, benthic invertebrates will be collected at each sampling station in the same manner as that conducted by the US Forest Service. The results and calculated metrics of community status calculated (60) will be compared to the US Forest Station data in the area of the Libby OU3 Site (PIPECK-02 and -03; BOBTAL-01; PRTZCK-02; WFQUAR-01; QRTZCK-01 and -02; Figure 6-1) as additional references.

6.3 Fish Sampling Methods and Procedures

Fish will be collected and identified from sixteen sampling locations including two in upper Rainy Creek (URC-1 and URC-2), six in lower Rainy Creek (LRC-1 to LRC-6), two in Fleetwood Creek (FC-1 and FC-2); two in Carney Creek (CC-1 and CC-2); one in the tailings pond (TP-1), one in the Fleetwood Creek Pond (FC-Pond), one in the Mill Pond (MP) and one in the pond on lower Carney Creek (CC-Pond). Samples will also be collected from a reference location. Fish will be collected according to the procedures specified in SOP# FISH-OU3 (Appendix B).

Fish from a subset of these locations (URC-2, LRC-1, LRC-3, LRC-5, FC-1, CC-1, TP and Ref) will be sacrificed and a gross necropsy performed and target tissues collected for possible future histopathology examination and the analyses of LA tissue burden. The target number of fish at each location is ten with two species represented. An effort will be made to collect the same species across sampling locations. The methods and procedures for gross necropsy and collection of tissue samples is provided in SOP#FISH-OU3 (Appendix B).

6.4 Small Mammal Sampling Methods and Procedures

Small mammals will be collected using procedures the specified in SOP#MAMMAL-OU3 (Appendix B). Small mammals will be collected by individuals that are experienced with the field trapping, collection, species identification and dissection of tissues.

6.5 Avian Sampling Methods and Procedures

Birds will be collected using procedures specified in SOP#BIRD-OU3 (Appendix B). Birds will be collected by individuals that are experienced with the use of mist nests, collection, species identification and dissection of tissues. Birds will be collected by individuals that are

7.0 LABORATORY TESTING REQUIREMENTS

The following subsections describe the laboratory testing requirements for samples collected under the SAP. Laboratory testing requirements include those for sediment toxicity testing, the identification and enumeration of benthic invertebrates and the histopathology examination of fish, mammalian and avian tissue samples.

7.1 Sediment Toxicity Testing Methods and Procedures

Sediments will be collected from the nine sampling locations (FC-1, FC-2, FC-Pond, URC-2, LRC-1, LRC-3, and LRC-5, CC-1 and Reference) for sediment toxicity testing. The sediments will be submitted to a qualified, experienced laboratory for toxicity testing with two species as specified in USEPA, 2000. The following tests will be completed according to the appropriate EPA Methods.

Sediment samples will be tested for toxicity using the amphipod *Hyalella azteca* in a 42 day test for measuring the effects of sediment associated contaminants on survival, growth and reproduction (EPA Test Method 100.4; USEPA, 2000).

Sediment samples will be tested for toxicity to the midge *Chironomus tentans* using the life-cycle test for measuring effects on survival, growth and reproduction (EPA Test Method 100.5; USEPA, 2000).

Both of these tests are conducted using longer term exposures than the typical 10 day tests with these organisms. The result of the longer term exposures can be more easily related to the population endpoints that are the goal of the assessment (USEPA, 2008c). Little is known concerning the potential effects of asbestos on aquatic organisms. Results of short-term tests would still leave questions concerning possible effects over longer exposure periods.

Based on the review of sediment sampling and analyses results from Phase I in the Problem Formulation, asbestos and a few metals are of potential concern. Based on the results of the Phase IIA sediment sampling (USEPA, 2008b) and this Phase IIC sediment testing, it may be necessary to consider sediment toxicity identification evaluation procedures if contaminants of concern other than asbestos are identified and sediment toxicity is observed. This testing would sort out and identify which contaminants are associated with any observed toxicity.

7.2 Benthic Macroinvertebrate Identification

Benthic invertebrate samples collected as described in Section 6.2 will be submitted to a qualified laboratory for identification and enumeration of species. The procedures for processing samples and identification are detailed in SOP#BMI-LIBBY-OU3. The laboratory will be responsible for preparation of voucher specimens.

7.3 Histopathology

Tissue samples collected from mammals and birds (and possibly fish) will be submitted to a qualified laboratory for histopathology examination. The histopathology examinations will be performed by board licensed veterinary pathologists. The pathology laboratory will receive the preserved tissues from the field and will be responsible for fixation and further preparation needed for the histology examination.

8.0 SAMPLE DOCUMENTATION

8.1 Field Documentation

Field documentation procedures are described in OU3 SOP No. 9. Field documentation associated with field sampling will also contain information of sufficient detail to fully describe:

- sample depth
- sampling method, and
- associated field measurements, including stream discharge if measured, and field measurement methods.

Field measurement values are generally reported directly in the units of final use in the field notebook and data sheets without need for additional calculations (e.g., pH, temperature, and conductivity measurements). The field data will be reviewed daily by the field supervisor to identify anomalous data and transcriptional and/or computational errors. Corrective actions will be initiated as appropriate; these actions may consist of re-measuring a particular parameter, collecting a new sample, or other applicable corrective action measures.

8.2 Sample Handling Instructions

8.2.1 Sample Containers

All sample containers used for sample collection and analysis for this project will be prepared according to the procedures contained in the EPA document, *Specifications and Guidance for Obtaining Contaminant-Free Sample Containers,* dated December 1992. This document specifies the acceptable types of containers, the specific cleaning procedures to be used before samples are collected, and requirements relevant to the containers and cleaning procedures. The analytical laboratories will supply all sample containers utilized for this investigation, both for asbestos and non-asbestos analyses. If field personnel observe any cracked or dirty containers, or if the appropriate preservative is missing in the sample bottles, those containers will be discarded and the laboratory will be notified of the problem to prevent its re-occurrence.

Table 8-1 lists the analysis methods used in Phase IIC for sediment samples.

8.2.2 Sample Preservation and Storage

Table 8-1 describes the sample preservation and storage requirements for solid media, respectively. Samples will be preserved using appropriate preservatives in order to prevent or minimize chemical changes that could occur during transit and storage. Solid samples (soil and sediment) typically do not require preservation other than temperature control during storage and transfer to the laboratory.

8.2.3 Sample Holding Times

A holding time is defined as the allowable time between sample collection and analysis and/or extraction recommended to ensure accuracy and representativeness of analysis results, based on the nature of the analyte of interest and chemical stability factors. The holding time is calculated from the date and time of sample collection to the time of sample preparation and/or analysis. Sample holding times are established to minimize chemical changes in a sample prior to analysis and/or extraction. Samples will be shipped to the laboratory as soon as possible after collection or processing. There are currently no EPA guidelines for holding times for solid samples analyzed for metals/metalloids and most other inorganic constituents, but a six-month holding time is recommended. There is no holding time requirement for asbestos.

Tables 8-1 defines the method-specific analytical holding times for solid media.

8.2.4 Sample Archival and Final Disposition

Unused samples and containers of environmental media will be maintained in storage at the laboratory for a minimum of 90 days following completion of the analysis, unless otherwise directed by EPA. Except as noted below, after 90 days or approval from EPA for disposal, the laboratory will be responsible for proper disposal of any remaining samples, sample containers, shipping containers, and packing materials in accordance with sound environmental practice, based on the sample analytical results. The laboratory will maintain proper records of waste disposal methods, and will have disposal company contracts on file for inspection.

Materials that shall not be disposed of but held in archive include:

- unanalyzed portions of filters and grids that have been prepared for asbestos analysis. These shall be held in archive at the asbestos analytical laboratory.
- the archive portion and three fine-ground aliquots of sediment samples will be shipped from the soil preparation laboratory to the analytical laboratory, where these materials will be held in archive until otherwise directed by EPA.

All data generated during the analysis of project samples must be stored by the laboratory for a period of ten years. Revised copies of the applicable SOPs and QAPPs must also be maintained and available should the data be required.

8.3 Sample Documentation and Identification

Data regarding each sample collected will be documented in accord with OU3 SOP No. 9 using Libby-specific field sample data sheets (FSDS). Any special circumstances that influence sample collection or result in deviations from sampling SOPs will be documented in a field log book.

At the time of collection, each sample will be labeled with a unique 5-digit sequential identification (ID) number. The sample ID for all samples collected as part of Phase II (including both Phase IIA and IIB) sampling activities will have a prefix of “P2” (e.g., P2-12345). Information on whether the sample is representative of a field sample or a field-based quality control (QC) sample (e.g., field blank, field split) will be documented on the FSDS, but this information will not be included on the chain-of-custody to make certain that the sample type is unknown to the analytical laboratory.

Each field sampling team will maintain a field log book. The log book shall record all potentially relevant information on sampling activities and conditions that are not otherwise captured on the FSDS forms. Examples of the type of information to be captured in the filed log include:

- Names of team members
- Current and previous weather conditions
- Field sketches
- Physical description of the location relative to permanent landmarks
- Number and type of samples collected
- Any special circumstances that influenced sample collection

As necessary for sample collection and location documentation, photographs will be taken using a digital camera. GPS coordinates will be recorded for all sampling locations on the FSDS form. A stake or pole identifying the sampling station will be placed at or near the sampling station for future identification of the location.

8.4 Sample Chain of Custody and Shipment

Field sample custody and documentation will follow the requirements described in OU3 SOP No. 9. Sample packaging and shipping will follow the requirements described in OU3 SOP No. 8.

A chain-of-custody form specific to the Phase IIA OU3 sampling shall accompany every shipment of samples to the analytical laboratory. The purposes of the chain-of-custody form are: a) to establish the documentation necessary to trace possession from the time of collection to final disposal, and b) to identify the type of analysis requested. All corrections to the chain-of-custody record will be initialed and dated by the person making the corrections. Each chain-of-custody form will include signatures of the appropriate individuals indicated on the form. The originals will accompany the samples to the laboratory and copies documenting each custody change will be recorded and kept on file. One copy of the chain-of-custody will be kept by field personnel.

All required paper work, including sample container labels, chain-of-custody forms, custody seals and shipping forms will be fully completed in ink (or printed from a computer) prior to shipping of the samples to the laboratory. Shipping to the appropriate laboratory from the field or sample storage will occur through overnight delivery.

All samples that may require special handling by laboratory personnel to prevent potential exposure to LA or other hazardous substances will be clearly labeled.

Upon receipt, the samples will be given to the laboratory sample custodian. The shipping containers will be opened and the contents inspected. Chain-of custody forms will be reviewed for completeness and samples will be logged and assigned a unique laboratory sample number. Any discrepancies or abnormalities in samples will be noted and the Laboratory Manger and the EPA Remedial Project Manager will be promptly notified.

Chain-of-custody will be maintained until final disposition of the samples by the laboratory and acceptance of analytical results.

9.0 LABORATORY ANALYSIS REQUIREMENTS

9.1 Analytical Methods for Asbestos

All laboratories that analyze samples of sediment or tissues for asbestos as part of this project must participate in and have satisfied the certification requirements in the last two proficiency examinations from the National Institute of Standards and Technology/National Voluntary Laboratory Accreditation Program (NVLAP). Laboratories must also have demonstrated proficiency by successful analysis of Libby-specific performance evaluation samples and/or standard reference materials, and must participate in the on-going laboratory training program developed by the Libby laboratory team.

Sample Preparation

All sediment samples collected for asbestos analysis will be transmitted to the CDM soil preparation laboratory in Denver, Colorado. Samples will be prepared in accordance with ISSI-LIBBY-01 Revision 10. In brief, the raw sediment sample is dried and then split into two aliquots. One aliquot is placed into archive, and the other aliquot is sieved into coarse (> ¼ inch) and fine fractions. The fine fraction is ground to reduce particles to a diameter of 250 um or less and this fine-ground portion is split into 4 aliquots.

Sample Analysis for Sediments

Each sediment sample will be analyzed for LA in accordance with Libby site-specific SOPs. The coarse fraction (if any) will be examined using stereomicroscopy, and any particles of LA will be removed and weighed in accordance with SRC-LIBBY-01 Revision 2. One of the fine ground fraction aliquots will be analyzed by polarized light microscopy (PLM) using the visual area estimation method (PLM-VE) in accordance with SRC-LIBBY-03 Revision 2. Mass fraction estimates and optical property details will be recorded on the Libby site-specific laboratory bench sheets and EDD spreadsheets.

Sample Analysis for Tissues

Each tissue sample will be analyzed for LA in accordance with Libby site-specific SOPs. Samples will be submitted for asbestos analysis using transmission electron microscopy (TEM) in accord with the International Organization for Standardization (ISO) 10312 method (ISO, 1995) counting protocols, with all applicable Libby site-specific laboratory modifications, including the most recent versions of modifications LB-000016, LB-000019, LB-000028, LB-000029, LB-000030, LB-000053, and LB-000066.

Sample Analysis for Duff

Duff samples were prepared by high temperature ashing to remove organic matter. The residue was then analyzed for LA by TEM. Results for duff samples are reported as a mass fraction of the mass of asbestos in grams to the mass of dried duff in grams.

9.2 Analytical Methods for Other (Non-Asbestos) Analytes

This section describes the laboratory analysis methods selected to provide non-asbestos chemical data to support the Phase IIA data quality objectives. Methods employed are derived from the following sources:

- *Test Methods for Evaluating Solid Waste Physical/Chemical Methods* (EPA, 1986)
- *Methods for Chemical Analysis of Water and Wastes* (EPA, 1994b)

Detailed calibration procedures and quality control practices associated with each referenced method are described later in Section 10.

The laboratories performing chemical analyses will be required to follow procedures for each referenced method in accordance with the method protocols in the original source documents. All method-specific quality control measures, such as external and internal standard calibration procedures, instrument performance verifications, and quantitation using method of standard additions, specified within any referenced EPA method number will be performed.

Non-asbestos analyses required for sediment samples are listed in Table 9-1. Analytes included under each method are identified in Table 3-5.

9.3 Instrument Calibration and Frequency

All laboratory instruments used in the analysis of samples generated during this project must be calibrated by the laboratory in accordance with the requirements of the instrument manufacturer and the requirements specified in the relevant analytical method. Calibration records will be kept in logbooks for all instruments. It is the responsibility of the Laboratory Quality Assurance (QA) Officer to assure that calibration data is properly logged in the logbooks for each analysis.

9.4 Laboratory Custody Procedures and Documentation

The laboratories will implement the following procedures:

- A sample custodian will be designated.
- Upon receipt at the laboratory, each sample shipment will be inspected to assess the condition of the shipping container and the individual samples.

- Enclosed chain-of-custody records will be cross-referenced with all the samples in the shipment. These records will be signed by the sample custodian and placed in the project file.
- Sample storage will be secured (in the appropriate environment, i.e., refrigerated, dry, etc.), sample storage records and intra-laboratory sample custody records will be maintained, and sample disposal and disposal date will be properly documented.
- Internal chain-of-custody procedures will be followed by assigning a unique laboratory number to each sample on receipt; this number identifies the sample through all further handling;
- Internal logbooks and records will maintain the chain-of-custody throughout sample preparation and analysis, and data reporting will be kept in the project files.
- The original chain-of-custody record will be returned to the Project QA Officer with the resulting data report from the laboratory.

It is the laboratory's responsibility to maintain internal logbooks and records throughout sample preparation, analysis, and data reporting.

9.5 Laboratory Health and Safety

All laboratories analyzing samples from OU3 must be properly trained in the safe handling, storage and disposal of samples that may contain LA and other potentially hazardous materials.

9.6 Documentation and Records

Data reports will be submitted to the Project Manager and include a case narrative that briefly describes the number of samples, the analyses, and any analytical difficulties or QA/QC issues associated with the submitted samples. The data report will also include signed chain-of-custody (COC) forms, analytical data summary report pages, and a summary of laboratory QC sample results and raw data, where applicable. Raw data are to consist of instrument preparation and calibration logs, instrument printouts of field sample results, laboratory QC sample results, calibration and maintenance records, COC check in and tracking, raw data count sheets, spectra, micrographic photos, and diffraction patterns.

9.7 Data Deliverables

Asbestos data generated during this project will be entered into Libby-specific EDD spreadsheets by appropriately trained data entry staff. The data to be captured will include all relevant field information regarding each environmental sample collected, as well as the analytical results provided by the laboratory. Analytical results will include the structure-specific data for all TEM analyses and optical properties data for all PLM analyses. All data entry will be reviewed and validated for accuracy by the laboratory data entry manager or appointed delegate.

Non-asbestos data generated for this project will be transmitted via an EDD spreadsheet. The specific structure and format of this spreadsheet will be specified by the project data manager and will be provided to the laboratory for data submittal. All data entry will be reviewed and validated for accuracy by the laboratory data entry manager or appointed delegate.

All asbestos and non-asbestos EDDs will be submitted to EPA technical contractors (SRC) electronically. Whenever possible, data files should be transmitted by e-mail to the following address:

LibbyOU3@syrres.com

When files are too large to transmit by e-mail, they should be provided on compact disk to the following address:

Lynn Woodbury
Syracuse Research Corporation
999 18th Street, Suite 1975
Denver CO 80202

All original data records (both hard copy and electronic) will be cataloged and stored in their original form until otherwise directed by the EPA Remedial Project Manager. At the termination of Phase IIC, all original data records will be provided to the EPA Remedial Project Manager for incorporation into the OU3 project files.

10.0 QUALITY CONTROL

Quality Control (QC) is a component of the QAPP, and consists of the collection of data that allow a quantitative evaluation of the accuracy and precision of the field data collected during the project. QC samples that will be collected during this project include both field-based and laboratory-based QC samples.

10.1 Field-Based Quality Control Samples

Field-based QC samples are those samples which are prepared in the field and submitted to the laboratory in a blind fashion. That is, the laboratory is not aware the sample is a QC sample, and should treat the sample in the same way as a field sample. In general, there are three types of field QC sample: blanks, field splits/duplicates, and performance evaluation (PE) samples. Table 10-1 summarizes the types and frequency of field QC samples which will be collected during Phase IIC.

10.1.1 Blanks

Field Blanks

A field blank is a sample of the same medium as field samples, but which does not contain any contaminant. Field blanks are collected for water samples, but not for sediment.

Equipment Rinsate Blanks

Equipment rinsate blanks determine if decontamination procedures of field equipment are adequate to prevent cross-contamination of samples during sample collection. An equipment rinsate blank is prepared by rinsing decontaminated field equipment with analyte-free reagent water. Equipment rinsate blanks will be collected at a rate of 1 per sampling team per day. If field equipment is not re-used between sampling locations (i.e., dedicated equipment is used or equipment is disposable and decontamination is not necessary), equipment rinsate blanks will not be collected.

10.1.2 Field Splits/Duplicates

A field split is a sample that is prepared by thoroughly homogenizing a field sample, dividing the homogenized sample into two parts, and analyzing each independently. A comparison of field split samples is a measure of the precision of the sample preparation and analysis methods.

A field duplicate is a field sample that is collected at the same place and time as an original field sample. However, because of potential variation in field duplicate samples (even those from similar locations, especially for media such as sediment), it is not appropriate to assume that field duplicate pairs must necessarily have the same or similar concentration values. Rather, field duplicates help to evaluate variability due to small-scale media heterogeneity, along with analytical precision.

Table 10-1 summarizes the frequency that field splits and duplicates will be collected for each media. In general, field splits/duplicates will be prepared at a rate of approximately 10% (1 field split/replicate per 10 field samples). The specific stations at which field splits/duplicates will be collected will be determined in the field based on sampling conditions.

10.1.3 Performance Evaluation (PE) Samples

Performance Evaluation (PE) samples are samples of a matrix that contain a known and certified level of a contaminant. The results of PE sample analysis help evaluate analytical accuracy. PE samples for water and soil are available through the EPA Quality Assurance Technical Support (QATS) program. A total of 2 soil PE sample containing a range of inorganic analytes will be added in random order to the field samples by the field collection teams.

PE samples for LA in soil are available from USGS. These PE samples were prepared by mixing uncontaminated soil samples from Libby with known amounts of LA collected from the mine, so the true mass fraction of LA is known. A total of 2 PE samples representing a range of LA levels will be added to the sediment sample preparation and analysis train in random order at the time of sediment sample preparation by the preparation laboratory.

10.2 Laboratory-Based Quality Control Samples for Asbestos Analysis by TEM

The QC requirements for TEM analyses of air samples at the Libby site are patterned after the requirements set forth by NVLAP. There are three types of laboratory-based QC analyses that are performed for TEM. Each of these is described in more detail below.

> *Lab Blank* - This is an analysis of a TEM grid that is prepared from a new, unused filter by the laboratory and is analyzed using the same procedure as used for field samples.

> *Recounts* - A recount is an analysis where TEM grid openings are re-examined after the initial examination. The type of recount depends upon who is performing the re-examination. A *Recount Same* (RS) describes a re-examination by the same microscopist who performed the initial examination. A *Recount Different* (RD) describes a re-examination by a different microscopist within the same laboratory than who performed the initial examination. An *Interlab* (IL) describes a re-examination by a different microscopist from a different laboratory.

Repreparation - A repreparation is an analysis of a TEM grid that is prepared from a new aliquot of the same field sample as was used to prepare the original grid. Typically, this is done within the same lab as did the original analysis, but a different lab may also prepare grids from a new piece of filter.

As described the most recent Libby-specific Laboratory Modification #29 (LB-000029), laboratory blanks will be performed at a frequency of 4%, recounts will be performed at a frequency of 5%, and repreparations will be performed at a frequency of 1%. Laboratory QC samples will be collected in accord with LB-000029, except that the minimum frequencies will apply to each individual media specifically collected at OU3 as summarized in Table 10-2.

10.3 Laboratory-Based Quality Control Samples for Asbestos Analysis by PLM

10.3.1 Preparation Laboratory QC Samples

Sediment preparation QC samples are collected to ensure proper sample handling and decontamination of sediment preparation equipment. Preparation QC samples are assigned unique field identifiers and are submitted blind to the analytical laboratory along with the field samples. Thus, the analytical laboratories cannot distinguish field samples from preparation QC samples. Two types of preparation QC samples are included for PLM analysis. Each of these is described in more detail below.

Preparation Blank – A preparation blank consists of asbestos-free quartz sand which is processed with each batch of field samples. A batch of samples is defined as a group of samples that have been prepared together for analysis at the same time (approximately 125). Preparation blanks determine if cross-contamination is occurring during sample preparation processing (i.e., drying, sieving, grinding, and splitting). The target number of preparation blanks is 1 per batch. All preparation blanks shall be PLM-VE Bin A (non-detect). If a preparation blank is ranked as a detect, the procedures for equipment decontamination between samples will be revised and revised as needed.

Preparation Splits – Preparation splits are prepared by dividing a sample into two parts after drying but prior to sieving and grinding. One preparation duplicate is included for every 20 field samples prepared. Because preparation splits may be authentically different due to within-sample heterogeneity, there are no acceptance criteria for preparation splits. Comparison of the results for preparation splits with the paired original field samples helps to evaluate the variability that arises during the preparation and analysis steps.

10.3.2 Analytical Laboratory QC Samples

As part of PLM-VE analysis, laboratory duplicate analyses will be prepared at a frequency of 10% (1 per 10 analyses). A *laboratory duplicate* is a re-preparation of a soil sample slide by a different analyst than who performed the initial analysis. Laboratory duplicates are performed to evaluate potential analytical differences between analysts. The acceptance criterion for laboratory duplicate analyses is that no more than 10% of all samples shall be discordant (assigned different PLM-VE bins). If the discordance rate is greater than 10%, laboratory procedures for sample examination and bin-assignment shall be reviewed and staff re-trained, as needed.

10.4 Laboratory-Based Quality Control Samples for Non-Asbestos Analyses

The following subsections describe laboratory-based quality control measures used to assess and document the quality of analytical results for non-asbestos parameters. Laboratory QC sample analysis frequencies and control limits used by contracted laboratories will be in accordance with referenced analytical method protocols, and the QC analyses and results will be documented and reported to EPA by the selected laboratory.

Table 10-2 summarizes all laboratory quality control measures, control limits, and corrective actions for this project, by analysis method. All laboratory QC data will be reported with results of associated sample analyses to allow for comparison of QC results to the QC criteria specified for this project.

10.4.1 Method Blank

Method blanks are designed to measure laboratory-introduced contamination of environmental samples. Method blanks verify that method interferences caused by airborne contaminants, solvents, reagents, glassware, or other sample processing hardware are known and minimized. The blank will be ASTM Type II water (or equivalent) for water samples. The method/reagent blank is processed through all procedures, materials, and lab-ware used for sample preparation and analysis.

The frequency for method blank preparation and analysis is a minimum of one per twenty field samples or per analytical batch, whichever is most frequent. An analytical batch is defined as samples which are analyzed together with the same method sequence and the same lots of reagents and with the manipulations common to each sample within the same time period or in continuous sequential time periods. Samples in each batch are to be of similar composition or matrix.

Acceptance criteria and corrective action for out-of-control method blanks are provided in Table 8-2.

10.4.2 Laboratory Control Samples

Laboratory control samples (LCSs) are designed to check the accuracy of the analytical procedure by measuring a known concentration of an analyte of interest. LCS samples are prepared by spiking clean, laboratory-simulated matrices (reagent-free water or purified solid matrix) with representative analytes at known concentrations that are approximately 10 times greater than the method's quantitation limits. These spiked samples are then subjected to the same preparation and analytical procedures as associated environmental samples. A LCS will be analyzed with every analytical batch, and the measured concentrations will be compared to the known, or spiked, concentrations of the LCS to compute a percent recovery value.

LCSs will be analyzed at a minimum frequency of one per every 20 samples or one per analytical batch of no more than 20 samples. Control limits for laboratory control samples are listed on Table 10-2. Failure of the LCS to meet recovery criteria requires corrective action before any further analyses can continue.

For some methods, a duplicate of the LCS is also analyzed with each analytical batch and the difference between the LCS and the LCS Duplicate (LCSD) indicates the precision of laboratory sample preparation and analysis methods at a known concentration level. Control limits for precision measured by the RPD of LCS/LCSD results are listed in Table 8-2. When LCSD samples are analyzed, the minimum frequency of analysis is one per every 20 samples.

10.4.3 Matrix Spikes/Matrix Spike Duplicates

Matrix spike/matrix spike duplicate (MS/MSD) samples are designed to evaluate the effect of the sample matrix on analytical data, by measuring precision and accuracy from a known concentration of a target analyte that has been added to a particular sample matrix. MS/MSD samples are prepared by spiking environmental field samples with a standard solution containing known concentrations of representative target analytes. The MS/MSD sample pair is prepared from three volumes of an environmental sample. Two portions of the sample (the MS and the MSD) are spiked with the standard solution. The remaining volume is not spiked. The spiked samples are analyzed, and the percent recovery (PR) and relative percent difference (RPD) between the results of the MS analysis and the MSD analysis are calculated. The unaltered sample volume is analyzed as an ordinary environmental sample.

Sampling personnel will identify for the laboratory which samples are to be used for MS/MSD preparation. Field blanks and field duplicates are not used as MS/MSDs. Typically, additional sample volume will be required to prepare the MS and MSD, especially for analyses of water samples for organic compounds. MS/MSDs will be analyzed at a minimum frequency of one per every 20 samples.

Background and interferences that have an effect on the actual sample analyte will have a similar effect on the spike. The calculated percent recovery of the matrix spike is considered to be a measure of the relative accuracy of the total analytical method, i.e., sample preparation and analysis. The matrix spike is also a measure of the effect of the sample matrix on the ability of the methodology to detect specific analytes. Acceptance criteria and corrective action procedures for out-of-control matrix spike results are listed in Table 10-2.

10.4.4 Surrogate Spike Analyses

Surrogate spike analyses are used to determine the efficiency of target analyte recovery during sample preparation and analysis. A surrogate spike is prepared by adding a known amount of surrogate compound to an environmental sample before extraction. The surrogate compound is selected to exhibit an analytical response that is similar to the response displayed by a target compound during sample analysis. The accuracy of the analytical method is measured using the calculated percent recovery of the spiking compound. Poor reproducibility and percent recovery during surrogate spike analyses may indicate sample matrix effects.

Surrogate compounds are not added to inorganic analyses; however, surrogates are required for most organic analyses. Both environmental and QC samples are spiked with surrogate compounds. Surrogate spike recoveries are acceptable if the results of a surrogate spike fall within the control limits established by laboratory QC protocol. Acceptance criteria and corrective action procedures for out-of-control surrogate spike results are listed in Table 10-2.

Frequencies for surrogate spike analyses will be consistent with the referenced method protocols.

10.4.5 Internal Standards

Internal Standards (ISs) are compounds of known concentrations used to quantitate the concentrations of target detections in field and QC samples. ISs are added to all samples after sample extraction or preparation. Because of this, ISs provide for the accurate quantitation of target detections by allowing for the effects of sample loss through extraction, purging, and/or matrix effects. ISs are used for any method requiring an IS calibration. Corrective action is required when ISs are out of control. Acceptance criteria and corrective action procedures for out-of-control internal standard spike results are listed in Table 10-2.

10.4.6 Instrument Calibration and Frequency

Analytical instruments will be calibrated in accordance with the referenced analytical methods. All target analytes that are reported to EPA will be present in the initial and continuing calibrations, and these calibrations must meet the acceptance criteria specified in referenced methods. Records of standard preparation and instrument calibration will be maintained by the contract laboratory. Records will unambiguously trace the preparation of standards and their use in calibration and quantitation of sample results. Calibration standards will be traceable to standard materials.

Analyte concentrations are determined with either calibration curves (linear regression) or response factors (RFs). All correlation coefficients for linear regression calibration curves or relative standard deviation (RSD) of RFs to determine linearity must meet the acceptability criteria specified within the method. For GC/MS methods, the average RF from the initial five-point calibration will be used to determine analyte concentrations. The continuing calibration curve will not be used to update the RFs from the initial five-point calibration. GC/MS methods also will meet all instrument performance and/or tuning criteria as specified by the methods.

Initial Calibration Verification

Initial calibration curves must be verified using a standard made from a source independent of the one used to make the initial calibration standards. All target compounds must be included within the initial calibration verification (ICV), typically at a concentration around the midpoint of the calibration curve. Control limits and corrective action procedures for out-of-control initial calibration verification results are listed in Table 10-2.

Continuing Calibration and Verification

Initial calibration curves must be verified daily prior to sample analysis. All target compounds must be included, typically at a concentration around the midpoint of the calibration curve. Continuing calibration verifications (CCVs) are check samples required at frequencies specified in each analytical method, typically at the beginning and end of each analytical sequence and after every ten samples analyzed (as specified in each analytical method). Control limits and corrective action procedures for out-of-control CCV results are listed Table 10-2.

Calibration procedures for a specific laboratory instrument will consist of initial calibration (3- or 5-points), initial calibration verification (ICV) and continuing calibration verification (CCV). Calibration protocols included in method references, including calibration frequencies, conditions, and acceptance criteria, will be followed.

10.5 Quality Assurance Objectives For Measurement Data

This section identifies specific objectives for precision, accuracy, representativeness, completeness, and comparability of measurement data collected to support the Phase I data quality objectives.

10.5.1 Precision

Precision is defined as the agreement between a set of replicate measurements without assumption or knowledge of the true value. Agreement is expressed as either the relative percent difference (RPD) for duplicate measurements, or the range and standard deviation for larger numbers of replicates. Precision will be assessed through the calculation of the relative percent difference (RPD) for two replicate samples. RPD is calculated according to the following formula:

$$RPD = \frac{(S - D)}{(S + D)/2} \cdot 100$$

where: S = Original sample value
D = Duplicate sample value

Field precision is assessed through the collection and measurement of field duplicates. The variability between field duplicates reflect the combined variation in concentration between nearby samples and the variation due to measurement error. Because the variability between field duplicates is random and may be either small or large, no quantitative requirement for the agreement of field duplicates is established for this project.

Precision in the laboratory is assessed through calculation of RPDs for duplicate analyses or relative standard deviations (RSDs) for three or more replicate analyses of the same sample. Results from mine waste, soil, and sediment duplicate samples are expected to be more variable than results from duplicate water samples due to the physical and chemical heterogeneity of the solid matrices. Based on this, an RPDs of 50% for mine waste, soil, sediment field duplicate samples and RPDs of 25% for water field duplicates will be used as advisory limits for analytes detected in both the original sample and its field duplicate at concentrations greater than 5 times the reported quantitation limit.

Differences greater than these advisory limits will be noted for data users through the data validation process.

10.5.2 Accuracy

Accuracy is a measure of the agreement between a measurement and the “true” value. The accuracy of a measurement may be affected by errors introduced by field contamination, sample preparation and handling, and sample analysis. The accuracy of an analytical method is generally assessed by analyses of samples with known concentration levels, including field calibration standards (for field based measurements), laboratory control samples, MS/MSD samples, and PE samples.

The accuracy required for data usability depends on a number of factors. In general, good accuracy is most important for samples whose concentration values are close to the level of concern, and a somewhat lesser level of accuracy may be acceptable for samples whose concentrations are either well below or well above a level of concern. Based on this, the goal is to achieve an analytical accuracy of ±25% for analytes that are within a factor of 10 of initial estimates of the level of concern, and ±50% for samples either 10-fold above or 10-fold below initial estimates of the level of concern.

10.5.3 Representativeness

Representativeness is the degree to which data accurately and precisely represent characteristics of a population, parameter variations at a sampling point, or an environmental condition. Representativeness of field measurements is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the SAP and SOPs are followed. The sampling activities in this plan are designed to provide data that are representative of conditions at specific locations and times of sample collection.

10.5.4 Completeness

Data are considered complete when a prescribed percentage of the total intended measurements and samples are obtained. Analytical completeness is defined as the percentage of valid analytical results requested.

Field completeness is a measure of the amount of valid measurement data collected for the project. The target completeness objective for field measurements collected for this sampling program is 95 percent or more.

Laboratory completeness is a measure of the amount of valid laboratory-measurement data obtained for the project. For this sampling program, a minimum of 90% percent of the planned collection of individual samples for quantification must be obtained to achieve a satisfactory level of data completeness.

10.5.5 Comparability

Data are comparable if collection techniques, measurement procedures, methods, and reporting units are equivalent for the samples within a sample set. These criteria allow comparison of data from different sources. Comparable data will be obtained by specifying standard units for physical measurements and standard procedures for sample collection, processing, and analysis.

The criteria for field comparability will be to ensure and document that the sampling designs are properly implemented and the sampling procedures are consistently followed for the duration of the data collection program. Each sampling task will utilize standardized procedures for sample collection and field measurements, as specified in Section 5 of this plan.

The criteria for laboratory data comparability will be to ensure that the laboratory results generated during this phase of investigation will be comparable to laboratory data collected for all other environmental investigations at OU3 and comparable to the asbestos data already collected by EPA in the vicinity of OU3. This goal will be achieved through utilization of standard EPA Test Methods and site-specific asbestos analysis methods for sample analyses and adherence to quality assurance/quality control and analytical procedures specified for the OU3 RI.

11.0 DATA MANAGEMENT

11.1 Data Applications

All data generated as part of the Phase IIC sampling event will be maintained in an OU3-specific Microsoft Access® database. This will be a relational database with tables designed to store information on station location, sample collection details, preparation and analysis details, and analytical results. Results will include asbestos data (including detailed structure attributes for TEM analyses and optical properties for PLM analyses) and non-asbestos chemical data (e.g., metals.

11.2 Roles and Responsibilities for Data Flow

11.2.1 Field Personnel

W.R. Grace contractors will perform all Phase IIC sample collection in accordance with the project-specific sampling plan and SOPs presented above. In the field, sample details will be documented on hard copy media-specific FSDS forms and in field log books (see Section 5.5). COC information will be documented on hard copy forms. FSDS and COC information will be manually entered into a field-specific[1] OU3 database using electronic data entry forms. Use of electronic data entry forms ensures the accuracy of data entry and helps maintain data integrity. For example, data entry forms utilize drop-down menus and check boxes whenever possible. These features allow the data entry personnel to select from a set of standard inputs, thereby preventing duplication and transcription errors and limiting the number of available selections (e.g., media types). In addition, entry into a database allows for the incorporation of data entry checks. For example, the database will allow a unique sample ID to only be entered once, thus ensuring that duplicate records cannot be created.

Entry of FSDS forms and COC information will be completed weekly, or more frequently as conditions permit. Copies of all FSDS forms, COC forms, and field log books will be scanned and posted in portable document format (PDF) to a project-specific file transfer protocol (FTP) site weekly. This FTP site will have controlled access (i.e., user name and password are required) to ensure data access is limited to appropriate project-related personnel. File names for scanned FSDS forms, COC forms, and field log books will include the sample date in the format YYYYMMDD to facilitate document organization (e.g., FSDS_20070831.pdf). Electronic copies of all digital photographs will also be posted weekly to the project-specific FTP site. File names for digital photographs will include the station identifier, the sample date, and photograph identifier (e.g., ST-1_20070831_12459.tif).

[1] The field-specific OU3 database is a simplified version of the master OU3 database. This simplified database includes only the station and sample recording and tracking tables, as well as the FSDS and COC data entry forms.

After FSDS data entry is completed, a copy of the field-specific OU3 database will be posted by the field data manager to the project-specific FTP weekly, or more frequently as conditions permit. The field-specific OU3 database posted to the FTP site will include the post date in the file name (e.g., FieldOU3DB_20070831.mdb).

11.2.2 Laboratory Personnel

Each of the laboratories performing asbestos analyses for the Phase IIA sampling event are required to utilize all applicable Libby-specific Microsoft® Excel spreadsheets for asbestos data recording and electronic submittals. Upon completion of the appropriate analyses, EDDs will be transmitted via email to a designated email distribution list within the appropriate turn around time. Hard copies of all analytical laboratory data packages will be scanned and posted as a PDF to the project-specific FTP site. File names for scanned analytical laboratory data packages will include the laboratory name and the job number to facilitate document organization (e.g., LabX_12365-A.pdf).

11.2.3 Database Administrators

Day-to-day operations of the master OU3 database will be under the control of EPA contractors. The primary database administrator will be responsible for sample tracking, uploading new data, performing error checks, and making any necessary data corrections. New records will be added to the master OU3 database within an appropriate time period of FSDS and/or EDD receipt.

Incremental backups of the master OU3 database will be performed daily Monday through Thursday, and a full backup will be performed each Friday. The full backup tapes will be stored off-site for 30 days. After 30 days, the tape will be placed back into the tape library to be overwritten by another full backup.

11.3 Data Storage

All original data records (both hard copy and electronic) will be cataloged and stored in their original form until otherwise directed by the EPA Remedial Project Manager. At the termination of this project, all original data records will be provided to the EPA Remedial Project Manager for incorporation into the site project files.

12.0 ASSESSMENT AND OVERSIGHT

Assessments and oversight reports to management are necessary to ensure that procedures are followed as required and that deviations from procedures are documented. These reports also serve to keep management current on field activities. Assessment, oversight reports, and response actions are discussed below.

12.1 Assessments

12.1.1 Field Oversight

All individuals who collect samples during field activities will be provided a copy of this SAP and will be required to participate in a pre-sampling readiness review meeting to ensure that methods and procedures called for in this SAP and associated SOPs are understood and that all necessary equipment is on hand. EPA may perform random and unannounced field audits of field sampling collection activities, as may be deemed necessary.

12.1.2 Laboratory Oversight

All laboratories selected for analysis of samples for asbestos will be part of the Libby analytical team. These laboratories have all demonstrated experience and expertise in analysis of LA in environmental media, and all are part of an on-going site-specific quality assurance program designed to ensure accuracy and consistency between laboratories. These laboratories are audited by EPA and NVLAP on a regular basis. Additional laboratory audits may be conducted upon request from the EPA, as may be needed.

12.2 Response Actions

If any inconsistencies or errors in field or laboratory methods and procedures are identified, response actions will be implemented on a case-by-case basis to correct quality problems. All response actions will be documented in a memo to the EPA RPM for OU3 at the following address:

Bonita Lavelle
U.S. EPA Region 8
1595 Wynkoop Street
Denver, CO 80202-1129
E-mail: lavelle.bonita@epa.gov

Any problems that cannot be corrected quickly through routine procedures may require implementation of a corrective action request (CAR) form.

12.3 Reports to Management

Field and analytical staff will promptly communicate any difficulties or problems in implementation of the SAP to EPA, and may recommend changes as needed. If any revisions to this SAP are needed, the EPA RPM will approve these revisions before implementation by field or analytical staff.

13.0 DATA VALIDATION AND USABILITY

13.1 Data Validation and Verification Requirements

Data validation, review, and verifications must be performed on sample results before distribution to the public for review.

Validation of Non-Asbestos Data

For non-asbestos analytical data, data validation will be performed in accord with the most current versions of EPA's National Functional Guidelines. In brief, the validation process consists of examining the sample data package(s) in order to determine if the data comply with the requirements specified in the National Functional Guidelines. The validator may examine, as appropriate, the reported results, QC summaries, case narratives, COC information, raw data, initial and continuing instrument calibration, and other reported information to evaluate the accuracy and completeness of the data package. During this process, the validator will determine if analytical methodologies were followed and QC requirements were met. The validator may recalculate selected analytical results to verify the accuracy of the reported information, as appropriate, and will assign qualifiers to the data as needed.

Verification of Asbestos Data

For asbestos analytical data, data verification includes checking that all required data have been entered on the laboratory bench sheets and field sample data sheets, and that results have been transferred correctly to the EDD. Some of the data verification checks are performed as a function of built-in quality control checks in the Libby-specific data entry spreadsheets. Additional verifications of field and analytical results will be performed manually by independent review of the bench sheets and FSDS. The initial frequency of manual review will be 10% of all samples. This initial rate may be revised either upward or downward depending on the frequency and nature of errors that are identified by the verification process.

13.2 Reconciliation with Data Quality Objectives

Once all samples have been collected and the analytical data have been reported and validated, the data will be reviewed by data users to determine if DQOs were achieved. A report of the data quality evaluation will be posted on the Libby OU3 site web page, when completed.

This page intentionally left blank to facilitate double-sided printing.

14.0 REFERENCES

Asbestos Hazardous Emergency Response Act (AHERA). 1986. Title 20, Chapter 52, Sec. 4011. Public Law 99-519.

Amandus H.E. and R. Wheeler R. 1987. The Morbidity and Mortality of Vermiculite Miners and Millers Exposed to Tremolite-Actinolite: Part II. Mortality. *Am. J. Ind. Med.* 11:15-26.

Agency for Toxic Substances and Disease Registry (ATSDR). 2001. *Toxicological Profile for Asbestos*. Atlanta, GA: Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services, Public Health Service.

Belanger, S. E. 1985. *Functional and pathological Responses of Selected Aquatic Organisms to Chrysotile Asbestos.* Doctoral Dissertation approved by Virginia Polytechnic Institute and State University, September 1985.

Corpet DE, Pirot V, Goubet I. 1993. Asbestos induces aberrant crypt foci in the colon of rats. *Cancer Letters*. 74(3): 183-187.

Cunningham, H. M., Moodie, C. A., Lawrence, G. A., and Pontefract, R. D. 1977. Chronic effects of ingested asbestos in rats. *Arch Environ Contam Toxicol*. 6(4): 507-13

Davis, J.M. and Jones, A.D. 1988. Comparisons of the pathogenicity of long and short fibers of chrysotile asbestos in rats. *British Journal of Experimental Pathology*. 69(5): 717-37.

Davis, J.M., J. Addison, and R. E. Bolton. 1986. The pathogenicity of long versus short fibre samples of amosite asbestos administered to rats by inhalation and intraperitoneal injection. *Br J Exp Pathol.* 67: 415-430.

Davis, J.M., Addison, J., Bolton, R.E., et al. 1985. Inhalation studies on the effects of tremolite and brucite dust in rats. *Carcinogenesis.* 6: 667-674.

Davis, J.M., Beckett, S.T., Bolton, R.E., et al. 1980a. The effects of intermittent high asbestos exposure (peak dose levels) on the lungs of rats. Br J Exp Pathol 61:272-280.

Davis, J.M., Beckett, S.T., Bolton, R.E., et al. 1980b. A comparison of the pathological effects in rats of the UICC reference samples of amosite and chrysotile with those of amosite and chrysotile collected from the factory environment. IARC Sci Publ 30:285-292

Donaldson K, Bolton RE, and A. Jones. 1988. Kinetics of the bronchoalveolar leucocyte response in rates during exposure to equal airborne mass concentrations of quartz, chrysolite asbestos, or titanium dioxide. *Thorax.* 43: 525-533.

International Organization for Standardization. 1995. *Ambient Air – Determination of asbestos fibres – Direct-transfer transmission electron microscopy method*. ISO 10312:1995(E).

Jones, C., W. J. McShea, M. J. Conroy and T. H. Kunz. 1996. Capturing Mammals. In Wilson, D.E, F. R. Cole, F.D. Nichols, R. Rudran and M.S. Foster (Eds), *Measuring and Monitoring Biological Diversity Standard Methods for Mammals.* Smithsonian Institution Press. Washington D.C. and London.

McDonald JC, Harris J, Armstrong B. 2004. Mortality in a cohort of vermiculite miners exposed to fibrous Amphibole in Libby, Montana. *Occup. Environ. Med*. 61:363-366.

McDonald JC, McDonald AD, Armstrong B, Sebastien P. 1986. Cohort study of mortality of vermiculite miners exposed to tremolite. *Brit. J. Ind. Med*. 43:436-444.

McGavran, P.D., Moore, L.B., and Brody, A.R. 1990. Inhalation of chrysotile asbestos induces rapid cellular proliferation in small pulmonary vessels of mice and rats. *American Journal of Pathology*. 136(3): 695-705.

Montana Department of Environmental Quality (MDEQ). 2003. Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases, October 2003. http://www.deq.state.mt.us/rem/hwc/rbca/NewRBCA11-2003/Tier1Guidance10-03.pdf

Meeker GP, Bern AM, Brownfield IK, Lowers HA, Sutley SJ, Hoeffen TM, Vance JS. 2003. The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana. *American Mineralogist.* 88: 1955-1969.

MWH Americas, Inc. (MWH). 2007. *Field Sampling Summary Report, Phase I Remedial Investigation Operable Unit 3, Libby Asbestos Superfund Site*. December 2007.

Quivik L.F., 2002. Expert Report. United States v. W.R. Grace Civil Action No.90-11-2-07106/2. July 29, 2002.

Peacock, P.R. and A. Peacock. 1965. Asbestos induced tumors in white leghorn fowls. *Annals New York Academy of Sciences*. 132(1): 501-6.

Pearson, D.E. and L. F. Ruggiero. 2003. Transect versus grid trapping arrangements for sampling small-mammal communities. *Wildlife Society Bulletin.* 31(2): 454-459.

Peipins LA, Lewin M, Campolucci S, Lybarger JA, Miller A, Middleton D, et al. 2003. Radiographic abnormalities and exposure to asbestos-contaminated vermiculite in the community of Libby, Montana, USA. *Environ. Health Perspect*. 111: 1753-1759.

Ralph, C.J. and E. H. Dunn (Ed). 2004. *Monitoring Bird Populations Using Mist Nets Studies in Avian Biology 29.* Cooper Ornithological Society. 211 pages.

Rohs AM, Lockey JE, Dunning KK, Shulka R, Fan H, Hilbert T, Borton E, Wiot J, Meyer C, Shipley RT, LeMasters GK, Kapol V. 2007. Low level Fiber Induced Radiographic Changes Caused by Libby Vermiculite: A 25 year Follow-up Study. *Am J Respiratory and Critical Care Medicine*. Published online December 6, 2007 as doi:10.1164/rccm.200706-814OC.

Sullivan PA. 2007. Vermiculite, Respiratory Disease and Asbestos Exposure in Libby, Montana: Update of a Cohort Mortality Study. *Environmental Health Perspectives* doi:10.1289/ehp.9481 available online at http://dx.doi.org.

U.S. Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste Physical/Chemical Methods and Updates I, II, IIA, IIB, III, IIIA and IIIB, EPA SW-846. http://www.epa.gov/epaoswer/hazwaste/test/main.htm

U.S. Environmental Protection Agency (EPA). 1991. *Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions.* Washington, DC. OSWER Directive 9355.0-30.

U.S. Environmental Protection Agency (EPA). 1994a. Method 100.2: *Determination of Asbestos Structures Over 10 um in Length in Drinking Water.* U.S. Environmental Protection Agency, Office of Research and Development. June 1994.

U.S. Environmental Protection Agency (EPA). 1994b. *Methods for the Determination of Metals in Environmental Samples, Supplement 1*. EPA/600/R-94/111. May 1994.

U.S. Environmental Protection Agency (EPA). 2000a. *Sampling and Quality Assurance Project Plan, Revision 1 for Libby, Montana, Environmental Monitoring for Asbestos, Baseline Monitoring for Source Area and Residential Exposure to Tremolite-Actinolite Asbestos fibers. January 2000.*

U.S. Environmental Protection Agency (EPA). 2000b. *Methods for Measuring Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates – Second Edition.* U.S. Environmental Protection Agency, Office of Research and Development. EPA 600/R-99/064. March 2000.

U.S. Environmental Protection Agency (EPA). 2001. *EPA Requirements for Quality Assurance Project Plans.* EPA QA/R-5. U.S. Environmental Protection Agency, Office of Environmental Information. EPA/240/B-01/003. March 2001.

U.S. Environmental Protection Agency (EPA). 2002. *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. U.S. Environmental Protection Agency. EPA-821-R-02-013. October, 2002.

U.S. Environmental Protection Agency (EPA). 2003. *Guidance for Developing Ecological Soil Screening Levels*. OSWER Directive 9285.7-55. November 2003. Revised February 2005

U.S. Environmental Protection Agency (EPA). 2005. *Characterization of Risks to Aquatic Receptors from Mining-Related Contaminants in the Upper Arkansas River, California Gulch Superfund Site, Operable Unit 12.* Report prepared by USEPA Region 8 with technical support from Syracuse Research Corporation. September 22, 2005.

U.S. Environmental Protection Agency (EPA). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process* – EPA QA/G4. U.S. Environmental Protection Agency, Office of Environmental Information. EPA/240/B-06/001. February 2006.

U.S. Environmental Protection Agency (EPA). 2007. Sediment Toxicity Identification Evaluation (TIE) – Phases I, II, and III Guidance Document. U.S. Environmental Protection Agency, National Health and Environmental Effects Research laboratory (NHEERL). EPA/600/R-xx/xxx. Draft – June 2007.

U.S. Environmental Protection Agency (EPA). 2008a. *Phase II Sampling and Analyses Plan for Operable Unit 3 Libby Asbestos Superfund Site. Part A: Surface Water and Sediment.* Prepared for the USEPA Region 8, Denver, Colorado with technical assistance from Syracuse Research Corporation and NewFields Boulder LLC, Boulder, CO. March 20, 2008.

U.S. Environmental Protection Agency (EPA). 2008b. *Phase II Sampling and Analyses Plan for Operable Unit 3 Libby Asbestos Superfund Site. Part A: Surface Water and Sediment.* Prepared for the USEPA Region 8, Denver, Colorado with technical assistance from Syracuse Research Corporation and NewFields Boulder LLC, Boulder, CO. March 20, 2008.

U.S. Environmental Protection Agency (EPA). 2008c. *Problem Formulation for Ecological Risk Assessment at Operable Unit 3 Libby Asbestos Superfund Site.* Prepared for the USEPA Region 8, Denver, Colorado with technical assistance from Syracuse Research Corporation and NewFields Boulder LLC, Boulder, CO. May 1, 2008.

U.S. Geological Survey (USGS). 1999. *Field Manual of Wildlife Diseases. General Field Procedures and Diseases of Birds.* Biological Resources Division Information and Technology Report 1999–001

U.S. Geological Survey (USGS). 1977. *National Handbook of Recommended Methods for Water-Data Acquisition.* Office of Water Data Coordination, U.S. Geological Survey, Department of the Interior, Reston, VA.

Vinson, M. 2007. *Aquatic Invertebrate Report for Samples Collected by the Kootenai National Forest, Summer 2006.* Report prepared for U.S. Forest Service, Kootenai National Forest, Canoe Gulch Ranger District, Libby, Montana. August 28, 2007.

Wagner JC, Berry G, Skidmore JW, et al. 1974. The effects of the inhalation of asbestos in rats. *Br J Cancer*. 29: 252-269.

Wagner JC, Berry G, Skidmore JW, et al. 1980. The comparative effects of three chrysotiles by injection and inhalation in rats. IARC Sci Publ 30: 363-372.

Ward TJ, T Spear, J Hart, C Noonan, A Holian, M Getman, and JS Webber. 2006. Trees as reservoirs for amphibole fibers in Libby, Montana. *Science of the Total Environment*. 367: 460–465.

Webster I, Goldstein B, Coetzee FS, et al. 1993. Malignant mesothelioma induced in baboons by inhalation of amosite asbestos. *Am J Ind Med.* 24(6): 659-666

W.R. Grace, 2006. Letter from Robert R. Marriam, Remedium, to Bonnie Lavelle, EPA dated August 2006.

Zinner E,R. 1982. Geohydrology of the Rainy Creek Igneous Complex Near Libby Montana. Masters Thesis Univeristy of Reno, Nevada. June 1982.

Zucker, G. 2006. Expert Report Prepared for W.R. Grace Company. Provided by Robert Marriam, Remedium correspondence to Bonita Lavelle, EPA, October 24, 2006.

This page intentionally left blank to facilitate double-sided printing.

Table 3-1. Analytical Methods for Surface Water

Category	Method	Analytes			
Metals		Aluminum	Beryllium	Copper	Selenium
		Antimony	Cadmium	Lead	Silver
	SW6020 & SW	Arsenic	Chromium	Manganese	Thallium
	6010B	Barium	Cobalt	Nickel	Vanadium
		Boron	Iron	Potassium	Zinc
		Calcium	Magnesium	Sodium	
	SW7470A	Mercury			
Pesticides	SW8081A	4,4´-DDD	beta-BHC	Endosulfan sulfate	Heptachlor
		4,4´-DDE	Chlordane	Endrin	Heptachlor epoxide
		4,4´-DDT	delta-BHC	Endrin aldehyde	Isodrin
		Aldrin	Dieldrin	Endrin ketone	Methoxychlor
		alpha-BHC	Endosulfan I	gamma-BHC (Lindane)	Toxaphene
		alpha-Chlordane	Endosulfan II	gamma-Chlordane	
	SW8151A	2,4,5-T	Dalapon	MCPA	
		2,4,5-TP (Silvex)	Dicamba	MCPP	
		2,4-D	Dichlorprop	Pentachlorophenol	
Organophosphorus Pesticides	8141A	Dichlorvos	Diazinon	Chlorpyrifos	Stirophos (Tetrachlorovinphos)
		Mevinphos	Disulfoton	Trichloronate	Bolstar (Sulprofos)
		Demeton-O,S	Dimethoate	Methyl Parathion	Fensulfothion
		Ethoprop (Prophos)	Ronnel	Mathion	EPN
		Phorate	Merphos	Tokuthion (Prothiofos)	Azinphos-methyl (Guthion)
		Sulfotep	Fenthion	Ethyl Parathion	Coumaphos
PCBs	SW8082	Aroclor 1016	Aroclor 1242	Aroclor 1260	
		Aroclor 1221	Aroclor 1248	Aroclor 1262	
		Aroclor 1232	Aroclor 1254	Aroclor 1268	
VOCs	SW8260B	1,1,1-Trichloroethane	1,3-Dichlorobenzene	Chlorodibromomethane	Methyl isobutyl ketone
		1,1,2,2-Tetrachloroethane	1,4-Dichlorobenzene	Chloroethane	Methyl tert-butyl ether (MTBE)
		1,1,2-Trichloro-1,2,2-trifluoroethane	1,4-Dioxane	Chloroform	Methylcyclohexane
		1,1,2-Trichloroethane	2-Hexanone	Chloromethane	Methylene chloride
		1,1-Dichloroethane	Acetone	cis-1,2-Dichloroethene	o-Xylene
		1,1-Dichloroethene	Benzene	cis-1,3-Dichloropropene	Styrene
		1,2,3-Trichlorobenzene	Bromochloromethane	Cyclohexane	Tetrachloroethene
		1,2,4-Trichlorobenzene	Bromodichloromethane	Dichlorodifluoromethane	Toluene
		1,2-Dibromo-3-chloropropane	Bromoform	Ethylbenzene	trans-1,2-Dichloroethene
		1,2-Dibromoethane	Bromomethane	Isopropylbenzene	trans-1,3-Dichloropropene
		1,2-Dichlorobenzene	Carbon disulfide	m+p-Xylenes	Trichloroethene
		1,2-Dichloroethane	Carbon tetrachloride	Methyl acetate	Trichlorofluoromethane
		1,2-Dichloropropane	Chlorobenzene	Methyl ethyl ketone	Vinyl chloride
SVOCs	SW8270C	1,2,4,5-Tetrachlorobenzene	3,3´-Dichlorobenzidine	bis(-2-chloroethyl)Ether	Hexachlorocyclopentadiene
		2,3,4,6-Tetrachlorophenol	3-Nitroaniline	bis(2-chloroisopropyl)Ether	Hexachloroethane
		2,4,5-Trichlorophenol	4,6-Dinitro-2-methylphenol	bis(2-ethylhexyl)Phthalate	m+p-Cresols
		2,4,6-Trichlorophenol	4-Bromophenyl phenyl ether	Butylbenzylphthalate	Nitrobenzene
		2,4-Dichlorophenol	4-Chloro-3-methylphenol	Caprolactam	n-Nitroso-di-n-propylamine
		2,4-Dimethylphenol	4-Chlorophenyl phenyl ether	Carbazole	n-Nitrosodiphenylamine
		2,4-Dinitrophenol	4-Nitroaniline	Dibenzofuran	o-Cresol
		2,4-Dinitrotoluene	4-Nitrophenol	Diethyl phthalate	p-Chloroaniline
		2,6-Dinitrotoluene	Acetophenone	Dimethyl phthalate	Pentachlorophenol
		2-Chloronaphthalene	Atrazine	Di-n-butyl phthalate	Phenol
		2-Chlorophenol	Benzaldehyde	Di-n-octyl phthalate	
		2-Nitroaniline	Biphenyl	Hexachlorobenzene	
		2-Nitrophenol	bis(-2-chloroethoxy)Methane	Hexachlorobutadiene	
PAHs	SW8270C	2-Methylnaphthalene	Benzo(a)pyrene	Dibenzo(a,h)anthracene	Naphthalene
		Acenaphthene	Benzo(b)fluoranthene	Fluoranthene	Phenanthrene
		Acenaphthylene	Benzo(g,h,i)perylene	Fluorene	Pyrene
		Anthracene	Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene	
		Benzo(a)anthracene	Chrysene	Isophorone	
Extractable hydrocarbons	MA-EPH	C11 to C22 Aromatics	C9 to C18 Aliphatics		
		C19 to C36 Aliphatics	Total Extractable Hydrocarbons		
	SW8015M	Total Extractable Hydrocarbons			
Volatile hydrocarbons	MA-VPH	C5 to C8 Aliphatics	Benzene	Methyl tert-butyl ether (MTBE)	
		C9 to C10 Aromatics	Ethylbenzene	Naphthalene	
		C9 to C12 Aliphatics	Toluene	m+p-Xylenes	
		Total Purgeable Hydrocarbons	Xylenes, Total	o-Xylene	
Nitrogen cmpds	E350.1	Nitrogen, Ammonia as N			
	E351.2	Nitrogen, Kjeldahl, Total as N			
	E353.2	Nitrogen, Nitrate+Nitrite as N			
	E353.2	Nitrogen, Nitrite as N	Nitrogen, Nitrate as N		
Radionuclides	E900.0	Gross Alpha			
	E903.0	Radium 226			
	RA-05	Radium 228			
	A7500-RA	Radium 226 + Radium 228			
Anions	E300.0	Chloride	Fluoride	Sulfate	
	E365.1	Orthophosphate as P			
	Kelada mod	Cyanide, Total			
Water quality parameters	A2320 B	Alkalinity, Total as CaCO3			
		Bicarbonate as HCO3			
		Carbonate as CO3			
		Hardness as CaCO3			
	A2540 C,D	Solids, Total Dissolved TDS	Solids, Total Suspended		
	A5310 C	Organic Carbon, Dissolved (DOC)			

Table 3-2. List of Surface Water Stations and Analyses

		Asbestos (LA)	Cations			Pesticides			PCBs	VOCs	SVOCs	PAHs	Pertroleum Hydrocarbons			Nitrogen Compunds				Radionuclides				Anions			Water quality parameters		
			TAL Metals		Hg								Extractable HC		Volatile HC	NH4	Total N	N02+NO3	NO2	Gross α	Ra226	Ra228	Ra226+228	Cl, F, SO4	PO4	CN	HCO3,CO3	TSS/ TDS	DOC
Reach	Station	EPA 100.2	SW6020	SW6010B	SW7470A	SW8081A	SW8151A	8141A	SW8082	SW8260B	SW8270C	SW8270C	MA-EPH	SW8015M	MA-VPH	E350.1	E351.2	E353.2	E353.2	E900.0	E903.0	RA-05	A7500-RA	E300.0	E365.1	Kelada	A2320 B	A2540C,D	A5310 C
Upper Rainy Creek	URC-1	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	URC-2	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
Tailings impoundment	TP	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	TP-TOE1	X	X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	TP-TOE2	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
Mill pond	MP	X	X	X	X									X	X				X					X	X		X	X	X
Lower Rainy Creek	LRC-1	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	LRC-2	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	LRC-3	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	LRC-4	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	LRC-5	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	LRC-6	X	X	X	X									X	X	X	X	X	X					X	X		X	X	
Fleetwood Creek	FC-1	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
	FC-Pond	X	X	X	X							X	X	X	X	X	X	X	X					X	X		X	X	X
	FC-2	X	X	X	X									X	X	X	X	X	X					X	X		X	X	X
Carney Creek	CC-1	X	X	X	X									X	X				X					X	X		X	X	X
	CC-2	X	X	X	X									X	X				X					X	X		X	X	X
Seeps	CCS-1	X	X	X										X	X	X	X	X	X					X	X		X	X	X
	CCS-6	X	X	X	X									X	X				X					X	X		X	X	X
	CCS-8	X	X	X	X									X	X				X					X	X		X	X	X
	CCS-9	X	X	X	X									X	X				X					X	X		X	X	X
	CCS-11	X	X	X	X									X	X				X					X	X		X	X	X
	CCS-14	X	X	X	X							X	X	X	X				X					X	X		X	X	X
	CCS-16	X	X	X	X									X	X				X					X	X		X	X	X

X= Sample analyzed

Table 3-3. Phase I Asbestos Results for Surface Water

Reach	Station	Sensitivity 1E-06/L	Total LA (MFL)				LA > 10 um in Length (MFL)			
			LA Count	Best Estimate	95% Conf. Bounds		LA Count	Best Estimate	95% Conf. Bounds	
Upper Rainy Creek	URC-1	0.05	0	<0	0.0	0.1	0	<0.05	0.0	0.1
	URC-2	0.11	52	5.8	4.3	7.5	1	0.1	0.0	0.5
Tailings Impoundment	TP	1.99	57	114	86.9	146.0	19	38	23.6	57.9
	TP-TOE1	0.05	0	<0.1	0.0	0.1	0	<0.05	0.0	0.1
	TP-TOE2	0.20	10	2.0	1.0	3.5	6	1.2	0.5	2.5
Mill Pond	MP	0.50	54	27	20.4	34.8	20	10	6.3	15.1
Lower Rainy Creek	LRC-1	0.05	4	0.2	0.1	0.5	0	<0.05	0.0	0.1
	LRC-2	0.05	2	0.1	0.0	0.3	1	0.05	0.0	0.2
	LRC-3	0.05	4	0.2	0.1	0.5	0	<0.05	0.0	0.1
	LRC-4	0.05	21	1.0	0.7	1.6	3	0.2	0.0	0.4
	LRC-5	0.05	25	1.2	0.8	1.8	2	0.1	0.0	0.3
	LRC-6	0.05	0	<0.1	0.0	0.1	0	<0.05	0.0	0.1
Fleetwood Creek	FC-1	0.08	51	3.9	2.9	5.1	12	0.9	0.5	1.6
	FC-Pond	2.49	50	125	93.5	162.7	3	7.5	2.1	19.9
	FC-2	0.05	4	0.2	0.1	0.5	1	0.05	0.0	0.2
Carney Creek	CC-1	0.05	20	0.9	0.6	1.4	7	0.3	0.1	0.7
	CC-2	0.05	1	0.00	0.0	0.2	1	0.05	0.0	0.2
Seeps	CCS-9	0.05	0	<0.1	0.0	0.1	0	<0.05	0.0	0.1
	CCS-8	0.05	0	<0.1	0.0	0.1	0	<0.05	0.0	0.1
	CCS-6	1.99	50	100	74.8	130.2	2	4.0	0.8	12.8
	CCS-1	0.14	53	7.5	5.7	9.8	3	0.4	0.1	1.1
	CCS-11	0.33	50	17	12.5	21.7	10	3.3	1.7	5.9
	CCS-14	0.20	55	11	8.3	14.2	0	<0.2	0.0	0.5
	CCS-16	0.08	0	<0.1	0.0	0.2	0	<0.08	0.0	0.2

TABLE 3-4. PHASE I NON-ASBESTOS RESULTS FOR SURFACE WATER

Category	Detected Analytes	Units	Detection Frequency (DF)	Mean Detection Limit (DL)	Concentration	
					Mean[1]	Max
Metals[†]	Barium	mg/L	24 / 24 100%	na	0.47	1.00
	Copper	mg/L	1 / 24 4%	0.002	0.0011	0.004
	Iron	mg/L	3 / 24 13%	0.03	0.071	1.34
	Manganese	mg/L	5 / 24 21%	0.02	0.045	0.66
	Vanadium	mg/L	1 / 24 4%	0.01	0.0052	0.01
	Calcium	mg/L	24 / 24 100%	na	82	131
	Magnesium	mg/L	24 / 24 100%	na	24	49
	Potassium	mg/L	24 / 24 100%	na	13	33
	Sodium	mg/L	24 / 24 100%	na	8	15
Volatile Hydrocarbons	Benzene	ug/L	1 / 24 4%	0.5	0.27	0.65
	C5 to C8 Aliphatics	ug/L	3 / 24 13%	20	13.6	62
	TPH	ug/L	3 / 24 13%	20	13.0	53
Extractable Hydrocarbons	TEH	mg/L	2 / 24 8%	0.30	0.17	0.47
Nitrogen Compounds	Nitrate	mg/L	10 / 15 67%	0.01	0.1	1.2
	Nitrite	mg/L	1 / 24 4%	0.01	0.0	0.01
Radionuclides	Gross Alpha	pCi/L	2 / 2 100%	na	2.1	2.5
Anions	Chloride	mg/L	22 / 24 92%	1	4.5	10
	Fluoride	mg/L	24 / 24 100%	na	0.4	0.9
	Sulfate	mg/L	24 / 24 100%	na	19.9	58
	PO4	mg/L	24 / 24 100%	na	0.2	1.16
Water Quality Parameters	Hardness as CaCO3	mg/L	20 / 20 100%	na	307	464
	Carbonate as CO3	mg/L	2 / 24 8%	4	2.5	11
	TDS	mg/L	24 / 24 100%	na	371	549
	TSS	mg/L	4 / 24 17%	10	7.8	36
	DOC	mg/L	23 / 23 100%	na	4.1	15

na = not applicable, all samples detected
TPH = Total Purgeable Hydrocarbons
TEH = Total Extractable Hydrocarbons
[†]Data presented in this table are based on the dissolved fraction for metals
[1] Mean calculated assuming 1/2 DL for NDs

Table 3-5. Phase I Analytical Methods for Sediment

Category	Method	Analytes			
Metals	SW6020 & SW6010B	Aluminum	Chromium	Selenium	
		Antimony	Cobalt	Silver	
		Arsenic	Copper	Thallium	
		Barium	Iron	Vanadium	
		Beryllium	Lead	Zinc	
		Boron	Manganese		
		Cadmium	Nickel		
	SW7471A	Mercury			
Pesticides	SW8081A	4,4´-DDD	beta-BHC	Endosulfan sulfate	Heptachlor
		4,4´-DDE	Chlordane	Endrin	Heptachlor epoxide
		4,4´-DDT	delta-BHC	Endrin aldehyde	Isodrin
		Aldrin	Dieldrin	Endrin ketone	Methoxychlor
		alpha-BHC	Endosulfan I	gamma-BHC (Lindane)	Toxaphene
		alpha-Chlordane	Endosulfan II	gamma-Chlordane	
	SW8151A	2,4,5-T	Dalapon	MCPA	
		2,4,5-TP (Silvex)	Dicamba	MCPP	
		2,4-D	Dichlorprop	Pentachlorophenol	
PCBs	SW8082	Aroclor 1016	Aroclor 1242	Aroclor 1260	
		Aroclor 1221	Aroclor 1248	Aroclor 1262	
		Aroclor 1232	Aroclor 1254	Aroclor 1268	
VOCs	SW8260B	1,1,1-Trichloroethane	1,3-Dichlorobenzene	Chlorodibromomethane	Methyl isobutyl ketone
		1,1,2,2-Tetrachloroethane	1,4-Dichlorobenzene	Chloroethane	Methyl tert-butyl ether (MTBE)
		1,1,2-Trichloro-1,2,2-trifluoroethane	1,4-Dioxane	Chloroform	Methylcyclohexane
		1,1,2-Trichloroethane	2-Hexanone	Chloromethane	Methylene chloride
		1,1-Dichloroethane	Acetone	cis-1,2-Dichloroethene	o-Xylene
		1,1-Dichloroethene	Benzene	cis-1,3-Dichloropropene	Styrene
		1,2,3-Trichlorobenzene	Bromochloromethane	Cyclohexane	Tetrachloroethene
		1,2,4-Trichlorobenzene	Bromodichloromethane	Dichlorodifluoromethane	Toluene
		1,2-Dibromo-3-chloropropane	Bromoform	Ethylbenzene	trans-1,2-Dichloroethene
		1,2-Dibromoethane	Bromomethane	Isopropylbenzene	trans-1,3-Dichloropropene
		1,2-Dichlorobenzene	Carbon disulfide	m+p-Xylenes	Trichloroethene
		1,2-Dichloroethane	Carbon tetrachloride	Methyl acetate	Trichlorofluoromethane
		1,2-Dichloropropane	Chlorobenzene	Methyl ethyl ketone	Vinyl chloride
SVOCs	SW8270C	1,2,4,5-Tetrachlorobenzene	3,3´-Dichlorobenzidine	bis(-2-chloroethyl)Ether	Hexachlorocyclopentadiene
		2,3,4,6-Tetrachlorophenol	3-Nitroaniline	bis(2-chloroisopropyl)Ether	Hexachloroethane
		2,4,5-Trichlorophenol	4,6-Dinitro-2-methylphenol	bis(2-ethylhexyl)Phthalate	m+p-Cresols
		2,4,6-Trichlorophenol	4-Bromophenyl phenyl ether	Butylbenzylphthalate	Nitrobenzene
		2,4-Dichlorophenol	4-Chloro-3-methylphenol	Caprolactam	n-Nitroso-di-n-propylamine
		2,4-Dimethylphenol	4-Chlorophenyl phenyl ether	Carbazole	n-Nitrosodiphenylamine
		2,4-Dinitrophenol	4-Nitroaniline	Dibenzofuran	o-Cresol
		2,4-Dinitrotoluene	4-Nitrophenol	Diethyl phthalate	p-Chloroaniline
		2,6-Dinitrotoluene	Acetophenone	Dimethyl phthalate	Pentachlorophenol
		2-Chloronaphthalene	Atrazine	Di-n-butyl phthalate	Phenol
		2-Chlorophenol	Benzaldehyde	Di-n-octyl phthalate	
		2-Nitroaniline	Biphenyl	Hexachlorobenzene	
		2-Nitrophenol	bis(-2-chloroethoxy)Methane	Hexachlorobutadiene	
PAHs	SW8270C	2-Methylnaphthalene	Benzo(a)pyrene	Dibenzo(a,h)anthracene	Naphthalene
		Acenaphthene	Benzo(b)fluoranthene	Fluoranthene	Phenanthrene
		Acenaphthylene	Benzo(g,h,i)perylene	Fluorene	Pyrene
		Anthracene	Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene	
		Benzo(a)anthracene	Chrysene	Isophorone	
Extractable hydrocarbons	MA-EPH	C11 to C22 Aromatics	C9 to C18 Aliphatics		
		C19 to C36 Aliphatics	Total Extractable Hydrocarbons		
	SW8015M	Total Extractable Hydrocarbons			
Volatile hydrocarbons	MA-VPH	C5 to C8 Aliphatics	Benzene	Methyl tert-butyl ether (MTBE)	
		C9 to C10 Aromatics	Ethylbenzene	Naphthalene	
		C9 to C12 Aliphatics	Toluene	m+p-Xylenes	
		Total Purgeable Hydrocarbons	Xylenes, Total	o-Xylene	
Sediment quality parameters	ASAM10-3.2	pH, sat. paste			
	SW3550A	Moisture			
	Leco	Carbon, Organic			

Table 3-6. List of Phase I Sediment Stations and Analyses

			Asbestos (LA)	Cations			Pesticides		PCBs	VOCs	SVOCs	PAHs	Pertroleum Hydrocarbons			Sediment quality parameters		
				TAL Metals		Hg							Extractable HC		Volatile HC	pH	Moisture	OC
Sample	Reach	Station	PLM-VE	SW6020	SW6010B	SW7470A	SW8081A	SW8151A	SW8082	SW8260B	SW8270C	SW8270C	MA-EPH	SW8015M	MA-VPH	ASAM10-3.2	SW3550A	Leco
1	Upper Rainy Creek	URC-1	X	X	X	X						X	X	X	X	X	X	X
2		URC-2	X	X	X	X						X	X	X	X	X	X	X
3	Tailings impoundment	TP	X	X	X	X						X	X	X	X	X	X	X
4		TP-TOE1	X	X	X	X								X	X	X	X	X
5		TP-TOE2	X	X	X	X	X	X	X	X	X			X	X	X	X	X
6	Mill pond	MP	X	X	X	X						X	X	X	X	X	X	X
7	Lower Rainy Creek	LRC-1	X	X	X	X	X	X	X					X	X	X	X	X
8		LRC-2	X	X	X	X	X	X	X	X	X			X	X	X	X	X
9		LRC-3	X	X	X	X	X	X	X			X	X	X	X	X	X	X
10		LRC-4	X	X	X	X	X	X	X					X	X	X	X	X
11		LRC-5	X	X	X	X	X	X	X					X	X	X	X	X
12		LRC-6	X	X	X	X	X	X	X			X	X	X	X	X	X	X
13	Fleetwood Creek	FC-1	X	X	X	X								X	X	X	X	X
		FC-Pond	X	X	X	X						X	X	X	X	X	X	X
14		FC-2	X	X	X	X						X	X	X	X	X	X	X
16	Carney Creek	CC-1	X	X	X	X						X	X	X	X	X	X	X
17		CC-2	X	X	X	X								X	X	X	X	X
18	Seeps	CCS-1	X	X	X	X								X	X	X	X	X
19		CCS-6	X	X	X	X								X	X	X	X	X
20		CCS-8	X	X	X	X						X	X	X	X	X	X	X
21		CCS-9	X	X	X	X								X	X	X	X	X
22		CCS-11	X	X	X	X						X	X	X	X	X	X	X
23		CCS-14	X	X	X	X								X	X	X	X	X
24		CCS-16	X	X	X	X						X	X	X	X	X	X	X

x = Sample analyzed

Table 3-7. Phase I Asbestos Results for Sediment

Reach	Station	ANALYTICAL RESULTS		
		$MF_{LA\%}$ fine	PLM-VE Bin	$MF_{LA\%}$ coarse
Upper Rainy Creek	URC-1	ND	Bin A	--
	URC-2	<1%	Bin B2	Tr
Tailings Impoundment	TP	<1%	Bin B2	Tr
	TP-TOE1	2%	Bin C	0.38%
	TP-TOE2	3%	Bin C	0.03%
Mill Pond	MP	<1%	Bin B2	--
Lower Rainy Creek	LRC-1	<1%	Bin B2	0.13%
	LRC-2	<1%	Bin B2	Tr
	LRC-3	2%	Bin C	--
	LRC-4	<1%	Bin B2	--
	LRC-5	<1%	Bin B2	Tr
	LRC-6	<1%	Bin B2	--
Fleetwood Creek	FC-2	Tr	Bin B1	ND
	FC-Pond	<1%	Bin B2	--
	FC-1	ND	Bin A	ND
Carney Creek	CC-2	<1%	Bin B2	0.20%
	CC-1	4%	Bin C	0.52%
Seeps	CCS-9	7%	Bin C	Tr
	CCS-8	6%	Bin C	0.41%
	CCS-6	2%	Bin C	Tr
	CCS-1	2%	Bin C	Tr
	CCS-11	<1%	Bin B2	0.20%
	CCS-14	<1%	Bin B2	Tr
	CCS-16	4%	Bin C	--

ND = not detected
Tr = trace
MF = mass fraction
-- = coarse fraction was not analyzed.

TABLE 3-8. PHASE I NON-ASBESTOS RESULTS FOR SEDIMENT

Category	Detected Analytes	Detection Frequency (DF)	Mean Detection Limit (DL) (mg/kg)	Concentration (mg/kg)	
				Mean[a]	Max
Metals	Aluminum	24 / 24 100%	na	12,419	33,800
	Arsenic	10 / 24 42%	2.00	2.1	7
	Barium	24 / 24 100%	na	844	4,930
	Chromium	24 / 24 100%	na	149	988
	Cobalt	23 / 24 96%	5.00	18	75
	Copper	24 / 24 100%	na	31	66
	Iron	24 / 24 100%	na	21,817	54,600
	Lead	23 / 24 96%	5.00	27	100
	Manganese	24 / 24 100%	na	1,240	12,700
	Mercury	2 / 24 8%	0.10	0.1	0.1
	Nickel	23 / 24 96%	5.00	37	226
	Selenium	4 / 24 17%	0.50	0.4	1.4
	Thallium	3 / 24 13%	0.60	0.5	4.3
	Vanadium	24 / 24 100%	na	45	105
	Zinc	24 / 24 100%	na	27	54
PAH	Pyrene	1 / 14 7%	0.87	0.4	1.2
VOC	Methyl acetate	2 / 2 100%	na	0.3	0.4
Extractable Hydrocarbons	C11 to C22 Aromatics	4 / 12 33%	24.41	63	436
	C19 to C36 Aliphatics	4 / 12 33%	25.63	71	350
	C9 to C18 Aliphatics	2 / 12 17%	26.40	28	162
	Total Extractable Hydrocarbons (MA-EPH)	4 / 12 33%	25.13	188	1,240
	Total Extractable Hydrocarbons (SW8015M)	23 / 24 96%	9.80	176	928
Volatile Hydrocarbons	C9 to C10 Aromatics	1 / 24 4%	3.86	2.3	10
	C9 to C12 Aliphatics	1 / 24 4%	3.95	2.0	10
	Total Purgeable Hydrocarbons	3 / 24 13%	3.65	2.9	17
Anions	Fluoride	5 / 24 21%	1.00	0.9	4.1
	Total Phosphorus	24 / 24 100%	na	2,564	10,200
Sediment Quality Parameters	pH, sat. paste	24 / 24 100%	na	7.2	8
	Moisture	24 / 24 100%	na	39.9	86
	Carbon, Organic	24 / 24 100%	na	2.5	15

na = not applicable

[a] Mean calculated assuming 1/2 DL for NDs

Table 3-9. Phase I Analytical Methods for Mine Waste & On-Site Soils

Category	Method	Analytes			
Metals	SW6020 & SW6010B	Aluminum	Chromium	Selenium	
		Antimony	Cobalt	Silver	
		Arsenic	Copper	Thallium	
		Barium	Iron	Vanadium	
		Beryllium	Lead	Zinc	
		Boron	Manganese		
		Cadmium	Nickel		
	SW7471A	Mercury			
Cyanide	SW9012	Total cyanide			
Pesticides	SW8081A	4,4´-DDD	beta-BHC	Endosulfan sulfate	Heptachlor
		4,4´-DDE	Chlordane	Endrin	Heptachlor epoxide
		4,4´-DDT	delta-BHC	Endrin aldehyde	Isodrin
		Aldrin	Dieldrin	Endrin ketone	Methoxychlor
		alpha-BHC	Endosulfan I	gamma-BHC (Lindane)	Toxaphene
		alpha-Chlordane	Endosulfan II	gamma-Chlordane	
	SW8151A	2,4,5-T	Dalapon	MCPA	
		2,4,5-TP (Silvex)	Dicamba	MCPP	
		2,4-D	Dichlorprop	Pentachlorophenol	
Organophosphorus Pesticides	8141A	Dichlorvos	Diazinon	Chlorpyrifos	Stirophos (Tetrachlorovinphos)
		Mevinphos	Disulfoton	Trichloronate	Bolstar (Sulprofos)
		Demeton-O,S	Dimethoate	Methyl Parathion	Fensulfothion
		Ethoprop (Prophos)	Ronnel	Mathion	EPN
		Phorate	Merphos	Tokuthion (Prothiofos)	Azinphos-methyl (Guthion)
		Sulfotep	Fenthion	Ethyl Parathion	Coumaphos
PCBs	SW8082	Aroclor 1016	Aroclor 1242	Aroclor 1260	
		Aroclor 1221	Aroclor 1248	Aroclor 1262	
		Aroclor 1232	Aroclor 1254	Aroclor 1268	
VOCs	SW8260B	1,1,1-Trichloroethane	1,3-Dichlorobenzene	Chlorodibromomethane	Methyl isobutyl ketone
		1,1,2,2-Tetrachloroethane	1,4-Dichlorobenzene	Chloroethane	Methyl tert-butyl ether (MTBE)
		1,1,2-Trichloro-1,2,2-trifluoroethane	1,4-Dioxane	Chloroform	Methylcyclohexane
		1,1,2-Trichloroethane	2-Hexanone	Chloromethane	Methylene chloride
		1,1-Dichloroethane	Acetone	cis-1,2-Dichloroethene	o-Xylene
		1,1-Dichloroethene	Benzene	cis-1,3-Dichloropropene	Styrene
		1,2,3-Trichlorobenzene	Bromochloromethane	Cyclohexane	Tetrachloroethene
		1,2,4-Trichlorobenzene	Bromodichloromethane	Dichlorodifluoromethane	Toluene
		1,2-Dibromo-3-chloropropane	Bromoform	Ethylbenzene	trans-1,2-Dichloroethene
		1,2-Dibromoethane	Bromomethane	Isopropylbenzene	trans-1,3-Dichloropropene
		1,2-Dichlorobenzene	Carbon disulfide	m+p-Xylenes	Trichloroethene
		1,2-Dichloroethane	Carbon tetrachloride	Methyl acetate	Trichlorofluoromethane
		1,2-Dichloropropane	Chlorobenzene	Methyl ethyl ketone	Vinyl chloride
SVOCs	SW8270C	1,2,4,5-Tetrachlorobenzene	3,3´-Dichlorobenzidine	bis(-2-chloroethyl)Ether	Hexachlorocyclopentadiene
		2,3,4,6-Tetrachlorophenol	3-Nitroaniline	bis(2-chloroisopropyl)Ether	Hexachloroethane
		2,4,5-Trichlorophenol	4,6-Dinitro-2-methylphenol	bis(2-ethylhexyl)Phthalate	m+p-Cresols
		2,4,6-Trichlorophenol	4-Bromophenyl phenyl ether	Butylbenzylphthalate	Nitrobenzene
		2,4-Dichlorophenol	4-Chloro-3-methylphenol	Caprolactam	n-Nitroso-di-n-propylamine
		2,4-Dimethylphenol	4-Chlorophenyl phenyl ether	Carbazole	n-Nitrosodiphenylamine
		2,4-Dinitrophenol	4-Nitroaniline	Dibenzofuran	o-Cresol
		2,4-Dinitrotoluene	4-Nitrophenol	Diethyl phthalate	p-Chloroaniline
		2,6-Dinitrotoluene	Acetophenone	Dimethyl phthalate	Pentachlorophenol
		2-Chloronaphthalene	Atrazine	Di-n-butyl phthalate	Phenol
		2-Chlorophenol	Benzaldehyde	Di-n-octyl phthalate	
		2-Nitroaniline	Biphenyl	Hexachlorobenzene	
		2-Nitrophenol	bis(-2-chloroethoxy)Methane	Hexachlorobutadiene	
PAHs	SW8270C	2-Methylnaphthalene	Benzo(a)pyrene	Dibenzo(a,h)anthracene	Naphthalene
		Acenaphthene	Benzo(b)fluoranthene	Fluoranthene	Phenanthrene
		Acenaphthylene	Benzo(g,h,i)perylene	Fluorene	Pyrene
		Anthracene	Benzo(k)fluoranthene	Indeno(1,2,3-cd)pyrene	
		Benzo(a)anthracene	Chrysene	Isophorone	
Extractable hydrocarbons	MA-EPH	C11 to C22 Aromatics	C9 to C18 Aliphatics		
		C19 to C36 Aliphatics	Total Extractable Hydrocarbons		
	SW8015M	Total Extractable Hydrocarbons			
Volatile hydrocarbons	MA-VPH	C5 to C8 Aliphatics	Benzene	Methyl tert-butyl ether (MTBE)	
		C9 to C10 Aromatics	Ethylbenzene	Naphthalene	
		C9 to C12 Aliphatics	Toluene	m+p-Xylenes	
		Total Purgeable Hydrocarbons	Xylenes, Total	o-Xylene	
Anions	E300.0	Fluoride			
	E365.1	Total Phosphorus			
Sediment quality parameters	ASAM10-3.2	pH, sat. paste			
	SW3550A	Moisture			
	Leco	Carbon, Organic			

Table 3-10. List of Phase I Mine Waste and Soil Stations and Analyses

			Asbestos (LA)	Cations			Total Cyanide	Pesticides			PCBs	VOCs	SVOCs	PAHs	Pertroleum Hydrocarbons			Anions		Sediment quality parameters		
				TAL Metals		Hg									Extractable HC		Volatile HC	Fluoride	Phosphorus	pH	Moisture	OC
Sample	Reach	Station	PLM-VE	SW6020	SW6010B	SW7471A	SW9012	SW8081A	SW8151A	8141A	SW8082	SW8260B	SW8270C	SW8270C	MA-EPH	SW8015M	MA-VPH	E300.0	E365.1	ASAM10-3.2	SW3550A	Leco
1	Road	MS-1	X	X	X	X					X			X	X	X	X	X	X	X	X	X
2		MS-2	X	X	X	X					X			X	X	X	X	X	X	X	X	X
3		MS-3	X	X	X	X					X			X	X	X	X	X	X	X	X	X
4	Tailings Impoundment	MS-4	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5		MS-5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	Coarse Tailings	MS-6	X	X	X	X										X	X	X	X	X	X	X
7		MS-7	X	X	X	X										X	X	X	X	X	X	X
8		MS-8	X	X	X	X										X	X	X	X	X	X	X
9		MS-9	X	X	X	X										X	X	X	X	X	X	X
10	Cover Material	MS-10	X	X	X	X										X	X	X	X	X	X	X
11		MS-11	X	X	X	X										X	X	X	X	X	X	X
12		MS-12	X	X	X	X										X	X	X	X	X	X	X
13		MS-13	X	X	X	X										X	X	X	X	X	X	X
14		MS-21	X	X	X	X										X	X	X	X	X	X	X
15		MS-22	X	X	X	X										X	X	X	X	X	X	X
16		MS-23	X	X	X	X										X	X	X	X	X	X	X
17		MS-24	X	X	X	X										X	X	X	X	X	X	X
18	Waste Rock	MS-14	X	X	X	X										X	X	X	X	X	X	X
19		MS-15	X	X	X	X										X	X	X	X	X	X	X
20		MS-16	X	X	X	X										X	X	X	X	X	X	X
21		MS-17	X	X	X	X										X	X	X	X	X	X	X
22		MS-18	X	X	X	X										X	X	X	X	X	X	X
23		MS-19	X	X	X	X										X	X	X	X	X	X	X
24		MS-20	X	X	X	X								X	X	X	X	X	X	X	X	X
25		MS-26	X	X	X	X										X	X	X	X	X	X	X
26		MS-27	X	X	X	X										X	X	X	X	X	X	X
27		MS-28	X	X	X	X										X	X	X	X	X	X	X
28		MS-29	X	X	X	X										X	X	X	X	X	X	X
29		MS-30	X	X	X	X										X	X	X	X	X	X	X
30		MS-32	X	X	X	X										X	X	X	X	X	X	X
31	Outcrop	MS-25	X	X	X	X												X	X	X	X	X
32		MS-31	X	X	X	X												X	X	X	X	X
33		MS-33	X	X	X	X												X	X	X	X	X
34		MS-34	X	X	X	X												X	X	X	X	X
35		MS-35	X	X	X	X												X	X	X	X	X
36		MS-36	X	X	X	X												X	X	X	X	X
37		MS-37	X	X	X	X												X	X	X	X	X
38		MS-38	X	X	X	X												X	X	X	X	X

x = Sample

Table 3-11. Phase I Asbestos Results for Mine Waste and On-Site Soils

Sampling Matrix	StationID	ANALYTICAL RESULTS		
		$MF_{LA\%}$ fine	PLM-VE Bin	$MF_{LA\%}$ coarse
Road	MS-1	<1%	Bin B2	Tr
	MS-2	<1%	Bin B2	Tr
	MS-3	Tr	Bin B1	Tr
Tailings Impoundment	MS-4	<1%	Bin B2	Tr
	MS-5	<1%	Bin B2	Tr
Coarse Tailings	MS-6	<1%	Bin B2	0.27%
	MS-7	2%	Bin C	1.00%
	MS-8	<1%	Bin B2	Tr
	MS-9	<1%	Bin B2	0.58%
Cover Material	MS-10	<1%	Bin B2	0.09%
	MS-11	<1%	Bin B2	0.07%
	MS-12	<1%	Bin B2	2.61%
	MS-13	Tr	Bin B1	Tr
	MS-21	<1%	Bin B2	Tr
	MS-22	<1%	Bin B2	0.43%
	MS-23	ND	Bin A	Tr
	MS-24	2%	Bin C	1.36%
Waste Rock	MS-14	<1%	Bin B2	3.70%
	MS-15	5%	Bin C	Tr
	MS-16	2%	Bin C	0.52%
	MS-17	<1%	Bin B2	1.10%
	MS-18	<1%	Bin B2	1.86%
	MS-19	<1%	Bin B2	0.82%
	MS-20	<1%	Bin B2	Tr
	MS-26	3%	Bin C	0.21%
	MS-27	<1%	Bin B2	1.88%
	MS-28	<1%	Bin B2	3.31%
	MS-29	2%	Bin C	1.26%
	MS-30	<1%	Bin B2	0.28%
	MS-32	<1%	Bin B2	1.68%
Outcrop	MS-25	8%	Bin C	1.73%
	MS-31	<1%	Bin B2	0.75%
	MS-33	<1%	Bin B2	0.16%
	MS-34	<1%	Bin B2	0.54%
	MS-35	Tr	Bin B1	0.006%
	MS-36	<1%	Bin B2	0.3%
	MS-37	<1%	Bin B2	0.2%
	MS-38	<1%	Bin B2	0.4%

Table 3-12. Non-Asbestos Results for Mine Waste and Soil

Category	Detected Analytes	Detection Frequency (DF)	Mean Detection Limit (DL)	Concentration (mg/kg)		Screening Benchmarks (mg/kg)					
				Mean[1]	Max	Plants		Soil Invertebrates		Wildlife[2]	
Metals	Aluminum	38 / 38 100%	na	17,874	50,900	pH-dep	3	pH-dep		pH-dep	3
	Antimony	1 / 38 3%	0.30	0.15	0.30	--		78		0.27	
	Arsenic	4 / 38 11%	2.00	1.16	3.00	18		--		43	
	Barium	38 / 38 100%	na	917	3,200	--		330		2,000	
	Chromium	38 / 38 100%	na	218	881	--		--		26	
	Cobalt	38 / 38 100%	na	27	63	13		--		120	
	Copper	37 / 38 97%	5.00	31	109	70		80		28	
	Iron	38 / 38 100%	na	24,905	51,900	pH-dep	4	pH-dep	4	pH-dep	4
	Lead	36 / 38 95%	5.00	19	50	120		1,700		11	
	Manganese	38 / 38 100%	na	357	808	220		450		4,300	
	Mercury	1 / 38 3%	0.10	0.06	0.30	--		--		0.161	
	Nickel	38 / 38 100%	na	57	135	38		280		130	
	Thallium	3 / 38 8%	0.60	0.34	0.90	--		--		--	
	Vanadium	38 / 38 100%	na	39	114	2		--		7.8	
	Zinc	38 / 38 100%	na	27	70	160		120		46	
PAHs	Benzo(a)anthracene	2 / 6 33%	0.37	0.13	0.21	na		--		na	
	Benzo(a)pyrene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Benzo(b)fluoranthene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Benzo(g,h,i)perylene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Benzo(k)fluoranthene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Chrysene	2 / 6 33%	0.37	0.13	0.21	na		--		na	
	Indeno(1,2,3-cd)pyrene	1 / 6 17%	0.30	0.13	0.21	na		--		na	
	Pyrene	2 / 6 33%	0.37	0.13	0.21	na		--		na	
	Total HMW-PAHs			1.02	1.68	--		18		100	
Pesticide	Pentachlorophenol	1 / 4 25%	0.31	0.13	0.25	5		31		2	
VOC	Methyl acetate	2 / 2 100%	na	1.13	1.7	--		--		--	
Extractable Hydrocarbons	C11 to C22 Aromatics	5 / 6 83%	13	33	78	--		--		--	
	C19 to C36 Aliphatics	6 / 6 100%	na	80	154	--		--		--	
	C9 to C18 Aliphatics	2 / 6 33%	11	17	53	--		--		--	
	TEH (MA-EPH)	6 / 6 100%	na	173	365	--		--		--	
	TEH (SW8015M)	22 / 30 73%	10.43	61.22	474	--		--		--	
Volatile Hydrocarbons	Toluene (MA-VPH)	1 / 30 3%	0.04	0.02	0.071	200		--		26	
	C5 to C8 Aliphatics	1 / 30 3%	1.66	0.85	1.4	--		--		--	
	C9 to C10 Aromatics	1 / 30 3%	1.66	1.33	16	--		--		--	
	Total Purgeable Hydrocarbons	3 / 30 10%	1.66	1.53	17	--		--		--	
Anions	Fluoride[6]	2 / 38 5%	1.0	0.73	5	--		--		--	
	Total Phosphorus[6]	38 / 38 100%	na	2,733	11,700	--		--		--	
Soil Quality Parameters	Carbon, Organic	38 / 38 100%	na	0.59	3	na		--		na	
	Moisture	38 / 38 100%	na	8.70	33	na		--		na	
	pH, sat. paste	38 / 38 100%	na	7.73	8.5	na		--		na	

na = not applicable

-- = not available

[1] Mean calculated assuming 1/2 DL for NDs

[2] From Attachment C

[3] Aluminum is considered to be a contaminant of potential concern under conditions where soil pH is less than 5.5. Minimum reported soil pH for the mine waste samples was 6.3.

[4] A numeric Eco-SSL for iron was not derived. The potential toxicity of iron in soils is dependant on soil pH and Eh.

[5] Based on the Montana Numerical Water Quality Standards (DEQ-7) Tier 1 Surface Soil RBSLs (mg/kg) < 10 feet to groundwater.

[6] Data not yet validated.

Table 3-13. Phase I Asbestos Results for Forest Soils

Transect ID	StationID	ANALYTICAL RESULTS		
		$MF_{LA\%}$ fine	PLM-VE Bin	$MF_{LA\%}$ coarse
SL45 Approximate downwind from mine area.	SL45-01	<1%	Bin B2	Tr
	SL45-02	ND	Bin A	Tr
	SL45-03	Tr	Bin B1	Tr
	SL45-04	ND	Bin A	ND
	SL45-05	ND	Bin A	ND
	SL45-06	ND	Bin A	ND
	SL45-07	ND	Bin A	ND
	SL45-08	ND	Bin A	ND
	SL45-09	ND	Bin A	ND
	SL45-10	ND	Bin A	ND
	SL45-11	ND	Bin A	--
	SL45-12	ND	Bin A	ND
	SL45-13	ND	Bin A	ND
	SL45-14	ND	Bin A	ND
	SL45-15	ND	Bin A	ND
	SL45-16	ND	Bin A	ND
SL15 30º counterclock-wise from approximate primary downwind direction.	SL15-02	Tr	Bin B1	ND
	SL15-03	Tr	Bin B1	Tr
	SL15-04	ND	Bin A	ND
	SL15-05	ND	Bin A	--
	SL15-06	ND	Bin A	ND
	SL15-07	ND	Bin A	ND
	SL15-08	ND	Bin A	ND
	SL15-09	ND	Bin A	ND
	SL15-10	ND	Bin A	ND
	SL15-11	ND	Bin A	ND
	SL15-12	ND	Bin A	ND
	SL15-13	ND	Bin A	--
	SL15-14	ND	Bin A	ND
	SL15-15	ND	Bin A	ND
	SL15-16	ND	Bin A	ND
SL75 30º clockwise from approximate primary downwind direction.	SL75-02	Tr	Bin B1	--
	SL75-03	ND	Bin A	ND
	SL75-04	Tr	Bin B1	ND
	SL75-05	ND	Bin A	ND
	SL75-06	ND	Bin A	ND
	SL75-07	ND	Bin A	ND
	SL75-08	ND	Bin A	ND
	SL75-09	ND	Bin A	ND
	SL75-13	ND	Bin A	--
	SL75-14	ND	Bin A	ND
	SL75-15	ND	Bin A	ND
	SL75-16	ND	Bin A	ND
SL195 Generally upwind of mine area/possibly downwind from Screening Plant.	SL195-02	ND	Bin A	ND
	SL195-03	ND	Bin A	ND
	SL195-04	ND	Bin A	ND
	SL195-05	ND	Bin A	ND
	SL195-06	ND	Bin A	ND
	SL195-07	ND	Bin A	Tr
	SL195-08	ND	Bin A	ND
	SL195-10	ND	Bin A	--
	SL195-11	ND	Bin A	ND
	SL195-12	ND	Bin A	ND
SL255 Approximate upwind direction from mine area.	SL255-02	ND	Bin A	Tr
	SL255-03	ND	Bin A	ND
	SL255-04	ND	Bin A	ND
	SL255-05	ND	Bin A	ND
	SL255-06	ND	Bin A	Tr
SL135 Across-gradient from primary downwind direction.	SL135-01	6%	Bin C	1.32%
	SL135-02	Tr	Bin B1	Tr
	SL135-03	ND	Bin A	ND
	SL135-04	ND	Bin A	ND
	SL135-05	ND	Bin A	ND
	SL135-06	ND	Bin A	ND
	SL135-07	ND	Bin A	ND
	SL135-08	ND	Bin A	ND
SL315 Across-gradient from primary downwind direction.	SL315-01	Tr	Bin B1	--
	SL315-02	ND	Bin A	ND
	SL315-03	ND	Bin A	ND
	SL315-04	ND	Bin A	ND
	SL315-05	ND	Bin A	ND
	SL315-06	ND	Bin A	ND
	SL315-07	ND	Bin A	ND
	SL315-08	ND	Bin A	ND

Table 3-14. Phase I Asbestos Results for Tree Bark

Transect ID	StationID	Approximate Distance From Mine (miles)	N LA	Sensitivity ($1/cm^2$)	Loading (MS/cm^2)	
					Total LA	PCME
SL45 Approximate downwind from mine area.	SL45-01	0.5	70	6.0E+04	4.22	0.42
	SL45-02	1.0	57	1.5E+04	0.86	0.21
	SL45-03	1.5	55	2.9E+04	1.59	0.29
	SL45-04	2.0	62	6.1E+04	3.79	1.28
	SL45-05	2.5	8	5.1E+03	0.04	0.01
	SL45-06	3.0	50	3.4E+04	1.70	0.54
	SL45-07	3.5	51	2.2E+05	11.25	2.65
	SL45-08	4.0	54	1.0E+04	0.55	0.18
	SL45-09	4.5	32	9.5E+03	0.30	0.09
	SL45-10	5.0	0	9.7E+03	<DL	<DL
	SL45-11	5.5	33	9.7E+03	0.32	0.14
	SL45-12	6.0	85	9.5E+03	0.80	0.11
	SL45-13	6.5	8	9.7E+03	0.08	0.02
	SL45-14	7.0	1	9.7E+03	0.01	<DL
	SL45-15	7.5	3	9.5E+03	0.03	0.02
	SL45-16	8.0	0	9.5E+03	<DL	<DL
SL15 30º counterclock-wise from approximate primary downwind direction.	SL15-02	1.0	58	5.8E+04	3.36	0.75
	SL15-03	1.5	61	2.0E+04	1.24	0.37
	SL15-04	2.0	53	3.1E+05	16.19	4.89
	SL15-05	2.5	51	2.0E+04	1.04	0.18
	SL15-06	3.0	53	3.1E+04	1.62	0.21
	SL15-07	3.5	50	3.2E+04	1.61	0.29
	SL15-08	4.0	16	9.0E+03	0.14	0.05
	SL15-09	4.5	10	9.0E+03	0.09	0.05
	SL15-10	5.0	4	9.0E+03	0.04	0.02
	SL15-11	5.5	0	9.5E+03	<DL	<DL
	SL15-12	6.0	0	9.7E+03	<DL	<DL
	SL15-13	6.5	0	9.5E+03	<DL	<DL
	SL15-14	7.0	0	9.5E+03	<DL	<DL
	SL15-15	7.5	0	1.3E+04	<DL	<DL
	SL15-16	8.0	0	9.5E+03	<DL	<DL
SL75 30º clockwise from approximate primary downwind direction.	SL75-02	1.0	6	7.3E+03	0.04	<DL
	SL75-03	1.5	108	1.2E+05	12.91	3.11
	SL75-04	2.0	44	8.7E+03	0.38	0.06
	SL75-05	2.5	66	6.1E+04	4.03	0.79
	SL75-06	3.0	57	7.6E+04	4.35	0.84
	SL75-07	3.5	6	8.7E+03	0.05	0.02
	SL75-08	4.0	28	8.7E+03	0.24	0.10
	SL75-09	4.5	36	9.4E+03	0.34	0.10
	SL75-13	5.0	6	9.0E+03	0.05	0.03
	SL75-14	5.5	13	8.7E+03	0.11	0.03
	SL75-15	6.0	30	8.7E+03	0.26	0.03
	SL75-16	6.5	9	9.4E+03	0.08	<DL
SL195 Generally upwind of mine area/possibly downwind from Screening Plant.	SL195-02	1.0	50	1.1E+05	5.67	1.48
	SL195-03	1.5	54	4.1E+04	2.20	0.77
	SL195-04	2.0	2	8.7E+03	0.02	0.01
	SL195-05	2.5	55	1.7E+04	0.96	0.37
	SL195-06	3.0	51	1.5E+04	0.78	0.23
	SL195-07	3.5	8	7.6E+03	0.06	0.02
	SL195-08	4.0	17	9.4E+03	0.16	0.04
	SL195-10	4.5	35	8.7E+03	0.31	0.10
	SL195-11	5.0	50	1.1E+04	0.53	0.08
	SL195-12	5.5	3	8.7E+03	0.03	0.02
SL255 Approximate upwind direction from mine area.	SL255-02	1.0	53	6.0E+04	3.17	0.42
	SL255-03	1.5	25	8.2E+03	0.21	0.06
	SL255-04	2.0	57	1.2E+05	6.61	1.39
	SL255-05	2.5	51	9.8E+03	0.50	0.08
	SL255-06	3.0	61	1.4E+05	8.84	1.88
SL135 Across-gradient from primary downwind direction.	SL135-01	0.5	127	6.1E+04	7.76	2.14
	SL135-02	1.0	64	1.2E+05	7.45	1.75
	SL135-03	1.5	53	1.0E+05	5.40	0.81
	SL135-04	2.0	52	8.1E+04	4.24	0.41
	SL135-05	2.5	33	9.0E+03	0.30	0.09
	SL135-06	3.0	51	4.7E+04	2.40	0.89
	SL135-07	3.5	13	9.0E+03	0.12	0.02
	SL135-08	4.0	19	9.4E+03	0.18	0.02
SL315 Across-gradient from primary downwind direction.	SL315-01	0.5	84	1.2E+05	9.91	4.25
	SL315-02	1.0	61	3.0E+04	1.82	0.39
	SL315-03	1.5	65	2.0E+04	1.32	0.31
	SL315-04	2.0	58	1.0E+04	0.59	0.15
	SL315-05	2.5	23	9.4E+03	0.22	0.04
	SL315-06	3.0	50	3.1E+04	1.53	0.21
	SL315-07	3.5	2	8.7E+03	0.02	0.01
	SL315-08	4.0	5	8.7E+03	0.04	0.03

FS = Field Sample

FD = Field Duplicate

Table 3-15. Age Data for Trees

Transect ID	StationID	Age of Tree (yrs)*	Approximate Distance From Mine (miles)
SL45 Approximate downwind from mine area.	SL45-08	51	4.0
	SL45-16	29	8.0
SL15 30º counterclock-wise from approximate primary downwind direction.	SL15-10	92	5.0
	SL15-11	100	5.5
	SL15-15	50	7.5
SL75 30º clockwise from approximate primary downwind direction.	SL75-04	79	2.0
	SL75-16	67	6.5
SL195 Generally upwind of mine area/possibly downwind from Screening Plant.	SL195-05	83	2.5
	SL195-08	48	4.0
SL255 Approximate upwind direction from mine area.	SL255-05	66	2.5
SL135 Across-gradient from primary downwind direction.	SL135-05	79	2.5
SL315 Across-gradient from primary downwind direction.	SL315-06	82	3.0

*Based on number of rings

MS/cm^2 = million structures per square centimeter

LA = libby amphibole

DL = detection limit

Table 5-1. Libby OU3 Phase IIC Ecological Sampling Program Elements

Program Element		Receptors	Description	Field Sampling Locations	Field Samples	Laboratory Analyses Required
1	Site-Specific Sediment Toxicity Testing	Benthic Invertebrates	Sediments collected and toxicity testing conducted with two organisms in 42 day exposures.	Fleetwood Creek (FC-2; FC-Pond) Upper Rainy Creek (URC-2) Lower Rainy Creek (LRC-1, LRC-3, LRC-5) Carney Creek (CC-1) Reference (Ref-1)	Grab samples of sediment	1) Asbestos and TAL metal residue in sediment 2) Toxicity testing of sediment
2	Population and Community Demographics	Benthic Invertebrates	Benthic invertebrates collected, enumerated and species identified. Metrics calculated according to EPA RBP and Biological Condition Score calculated for each sampling location and compared to reference.	Upper Rainy Creek (URC-1A, URC-2) Lower Rainy Creek (LRC-1 to LC-6) Fleetwood Creek (FC-1; FC-2) Carney Creek (CC-1; CC-2) Reference (Ref-1)	1) Composite samples collected according to EPA RBP[1]. 2) Three surber samples collected for comparison to Forest Service Data[2]	Benthic invertebrate identification and enumeration
		Fish	Fish collected and species identified and enumerated and size recorded. Sub sample of fish	Upper Rainy Creek (URC-2) Lower Rainy Creek (LRC-1 to LC-6) Fleetwood Creek (FC-1; FC-2; FC-Pond) Carney Creek (CC-1; CC-2; CC-Pond) Reference (Ref-1)	None	None
		Small Mammals	Small mammals will be collected over a five day trapping period. The species and number of individuals captured will be recorded.	Site 1: On-Site Site 2: Nearby Forested Area Site 3: Riparian Area Site 4: Reference	None	None
		Birds	Birds will be collected from each of four areas over a five day sampling period. The species and number of individuals captured will be recorded.	Site 1: On-Site Site 2: Nearby Forested Area Site 3: Riparian Area Site 4: Reference	None	None
3	In-Situ Measures of Exposure and Effect	Fish	A subsample of the fish collected will be sacrificed. A gross necropsy will be performed with specific tissues dissected in the field and preserved for histopathology and asbestos tissue residue analyses.	Upper Rainy Creek (URC-2) Lower Rainy Creek (LRC-1; LRC-3; LRC-5) Fleetwood Creek (FC-1) TP (TP-1) Carney Creek (CC-1) Reference (Ref-1)	Selected tissues	Held for possible for histopathology and asbestos residue
		Small Mammals	A subsample of the small mammals collected will be sacrificed. A gross necropsy will be performed with specific tissues dissected in the field and preserved for histopathology and asbestos tissue residue analyses.	Site 1: On-Site Site 2: Nearby Forested Area Site 3: Riparian Area Site 4: Reference	1) Selected tissues in sub sample of collected mammals 2) Duff along transects	1) Histopathology of selected tissues 2) Asbestos residue in duff

Table 5-1. Libby OU3 Phase IIC Ecological Sampling Program Elements						
Program Element		Receptors	Description	Field Sampling Locations	Field Samples	Laboratory Analyses Required
		Birds	A sub sample of the birds collected will be sacrificed. A gross necropsy will be performed with specific tissues dissected in the field and preserved for histopathology and asbestos tissue residue analyses.	Site 1: On-Site Site 2: Nearby Forested Area Site 3: Riparian Area Site 4: Reference	1) Selected tissues in sub sample of collected mammals 2) Duff along transects	Histopathology Asbestos Residue

Table 5-2
Libby OU3 Phase IIC - Rainy Creek Watershed Ecological Sampling Summary

Station ID		Station Description	Asbestos in Sediment [1] $MF_{LA\%}$ fine	Chromium in Sediment [1] mg/kg	Phase IIA SW/SD Data [2]	Surface Water Toxicity Testing [2]	Sediment Toxicity Testing	Benthic Invert. Community	Fish Population Demographics	Fish Histopath/ Asbestos Tissue Burden
Rainy Creek	URC-1	Upper Rainy Creek above Mine Area	ND	6	√					
	URC-1A	Upper Rainy Creek above Mine Area 100 yards north of Rainy Creek Rd.	NS	NS	√			√		
	URC-2	Upper Rainy Creek above Mine Area	<1%	32.8	√		√	√	√	H
	LRC-1	Lower Rainy Creek above confluence with Carney Creek	<1%	148	√		√	√	√	H
	LRC-2	Lower Rainy Creek below confluence with Carney Creek	<1%	135	√			√	√	
	LRC-3	Lower Rainy Creek	2%	233	√		√	√	√	H
	LRC-4	Lower Rainy Creek	<1%	38.8	√			√	√	
	LRC-5	Lower Rainy Creek	<1%	129	√		√	√	√	H
	LRC-6	Lower Rainy Creek just above confluence with the Kootenai River	<1%	126	√			√	√	
Fleetwood Creek	FC-1	Fleetwood Creek above Mine Area	ND	14.6	√		√	√	√	H
	FC-2	Fleetwood Creek above Tailings Impoundment	Tr	21	√			√	√	
	FC-Pond	Pond on Fleetwood Creek	<1%	289	√		√		√	
Tailings Impoundment	TP	Tailings Impoundment	<1%	110	√	√			√	H
	UTP	Upper Tailings Impoundment	NS	NS	√					
	TP-TOE1	Toe drain of impoundment	2%	43	√					
	TP-TOE2	Toe drain flow to Rainy Creek below diversion	3%	213	√					
	TP-Overflow	In the overflow ditch from tailings impoundment	NS	NS	√					
Mill Pond	MP	Mill Pond	<1%	48	√				√	

Table 5-2
Libby OU3 Phase IIC - Rainy Creek Watershed Ecological Sampling Summary

Station ID		Station Description	Asbestos in Sediment [1] $MF_{LA\%}$ fine	Chromium in Sediment [1] mg/kg	Phase IIA SW/SD Data [2]	Surface Water Toxicity Testing [2]	Sediment Toxicity Testing	Benthic Invert. Community	Fish Population Demographics	Fish Histopath/ Asbestos Tissue Burden
Carney Creek	CC-1	Carney Creek	4%	77.2	√		√	√	√	
	CC-2	Carney Creek just above confluence with Rainy Creek	<1%	43.3	√			√	√	
	CC-Pond	Pond on lower Carney Creek	NS	NS	√				√	
Reference		Reference Location	NS	NS			√	√	√	H

[1] Data are from the Phase I Sampling and Analyses.
[2] Proposed in Phase IIA Sampling and Analyses Plan (SAP) (USEPA, 2008b)
MF = millions of fibers
LA = Libby amphibole
H = Samples will be collected and preserved and held for possible later histopathological examination.

TABLE 5-3 Histological Lesions in Fish Exposed to Asbestos

Reference	Species	Asbestos type	Exposure	Response Site	Observed Pathology	Gross Adverse Effect
Belanger et al. 1986	Coho Salmon	Chrysotile	5E+06 fibers/L	Lateral Line	Distortion, erosion, tumorous swelling and coelomic distention	Adverse rheotaxic behavior (fish could not swim)
	Japanese Medaka	Chrysotile	1E+06 fibers/L	Epidermis	Increased thickening	Decreased growth, increased mortality
Yasutake 1982,1983	Multiple species	Chrysotile Amosite	1E+06 fibers/L 1E+09 fibers/ L	Gill	Lamella aneurysm, epithelial hypertrophy, hyperplasia, sloughing, degeneration, necrosis	No data
				Epidermis	Sloughing, reduction in mucus cells	
				Kidney	Amorphous foreign bodies, extensive intracytoplamic ceroid-like material in epitehelial cel1s of renal tubules	
				Muscle	Fiber degeneration	
Woodhead et al. 1983	Amazon molly	Chrysotile	1mg/L	Heart	Vacuolation and necrosis of the sarcoplasm of the bulbus arteriosus	None
				Kidneys, gills	Lesions	None

Table 5-4
Wildlife Exposed Receptor Groups and Species Targeted for Collection

Exposed Receptor Group		Description of Exposed Group	Species in Group Common name *(Genus species)*	Number Reported[1,2]	Estimated Longevity[2,3]	BW (grams)[2]	Estimated Home Range[2]
Mammalian	Ground Invertivore	Mammalian invertivorous species that feed primarily on soil invertebrates, forage on the ground and may inhabit underground burrows.	Dusky or Montane Shrew (*Sorex monticolus*)	7	18 months	6	1227 m^2 for nonbreeders, 4020 m^2 for breeders
			Masked Shrew (*Sorex cinereus*)	16	estimated to live up to 1.8 years	5	About 0.10 acres
			Pygmy Shrew (*Sorex hoyi*)	4		4	
			Vagrant Shrew (*Sorex vagrans*)	39	estimated to live up to 1.5 years	9	1039 m^2 for nonbreeding and 3258 m^2 for breeding
	Arboreal Invertivore	Mammalian invertivorous and omnivorous species that feed primarily in trees.	Northern Flying Squirrel (*Glaucomys sabrinus*)			125	Home range varies; reported range from 2-13 ha
			Red-tailed Chipmunk (*Tamias ruficaudus*)		Up to 6 to 8 years	60	Not more than a few hundred meters across
	Ground Herbivore/Omnivore	Mammalian herbivorous species that feed primarily on plant material, forage on the ground and may inhabit burrows or nests on the ground.	Bushy-tailed Woodrat (*Neotoma cinerea*)	4		44	averaged 6.1 ha for males, 3.6 ha for females
			Columbian Ground Squirrel (*Spermophilus columbianus*)	12	Sexually mature in 1-2 years; 22-33% survive to maturity	812	Average home range of adult male was about 0.4 ha, of adult female about 0.1 ha.
			Deer Mouse (*Peromyscus maniculatus*)	60	estimated to live less than 2 years	33	averages 1 ha or less, may range from a few hundred to a few thousand sq m, depending on circumstances.
			Golden-mantled Ground Squirrel (*Spermophilus lateralis*)	2	up to 7 years	276	
			Heather Vole (*Phenacomys intermedius*)	15	Estimated to live up to 4 years	41	
			Hoary Marmot (*Marmota caligata*)	12		9000	
			Long-tailed Vole (*Microtus longicaudus*)	13	seldom lives more than one year	58	
			Mountain Cottontail (*Sylvilagus nuttallii*)		7.4 years in captivity	1032	
			Northern Pocket Gopher (*Thomomys talpoides*)	1	seldom lives for more than two years	130	150-200 sq yards
			Pika (*Ochotona princeps*)	12	7 years	128	home range varies seasonally; reported range from 0.04-0.5 ha
			Red Squirrel (*Tamiasciurus hudsonicus*)	19		252	1 to 6 acres
			Southern Red-backed Vole (*Clethrionomys gapperi*)	35		42	0.25-3.5 acres
			Snowshoe Hare (*Lepus americanus*)	1	Lives usually no more than about 2 years, but up to about 5 years.	1400	Home range size varies with location and season; most studies indicate a home range size averaging 5-20 ha
			Yellow-bellied Marmot (*Marmota flaviventris*)	3	May live up to 15 years	4500	Home range size varies; reported range from 0.06 to 47.5 ha
			Yellow pine chipmunk (*Tamias amoenus*)	10	May live up to 5 years	73	few acres
			Western Jumping Mouse (*Zapus princeps*)	17	May live up to 4 years	38	0.2-0.6 ha
Avian	Ground Invertivore	Avian insectivorous species that feed primarily on soil invertebrates.	American robin (*Turdus migratorius*)	828	4 to 11.5 years	77	
			Common Yellowthroat (*Geothlypis trichas*)	37	11.5 years	10	
			Flammulated Owl (*Otus flammeolus*)	32	7 to 8 years	57	vary from 5.5 to 24.0 hectares
			House Wren (*Troglodytes aedon*)	16	5 to 7 years	11	
			Killdeer (*Charadrius vociferus*)	19	10.9 years	101	
			Nashville Warbler (*Vermivora ruficapilla*)	58	10.2 years	9	
			Northern Flicker (*Colaptes auratus*)	575	12.5 years	142	
			Rock Wren (Salpinctes obsoletus)	11		17	
			Spotted Towhee (*Pipilo maculatus*)	78	10.7 years	42	
			Townsend's Solitaire (*Myadestes townsendi*)	515		34	
			Warbling Vireo (*Vireo gilvus*)	435	13.1 years	12	
			Winter Wren (*Troglodytes troglodytes*)	487	5.75 years	9	
			Western Bluebird (*Sialia mexicana*)	11	6.1 years	29	Approximately 0.4 to 0.6 ha
	Arboreal Invertivore	Avian species that feed primarily in trees on invertebrates.	American Redstart (*Setophaga ruticilla*)		10.1 years	9	0.6-2 ha
			American Three-toed Woodpecker *Picoides dorsalis*)			70	74 acres
			Black-backed Woodpecker (*Picoides arcticus*)			72	varies; range 30-328 ha
			Black-capped Chickadee (*Poecile atricapillus*)		average longevity is 2.5 years; record longevity in the wild is 12.4 years	11	8-9 ha
			Brown Creeper (*Certhia Americana*)		estimated to live up to 4.6 years	8	approximately 2-6 ha
			Chestnut-backed Chickadee (*Poecile rufescens*)		9.5 years	10	
			Downy Woodpecker (*Picoides pubescens*)		4 to 10.5 years	27	
			Golden-crowned Kinglet (*Regulus satrapa*)		5.3 years	6	about 2-6 acres
			Orange-crowned Warbler (*Vermivora celata*)		8.5 years	9	
			Pileated Woodpecker (*Dryocopus pileatus*)		13 years	308	about 50 - 250 ha
			Pygmy Nuthatch (*Sitta pygmaea*)		8.2 years	11	
			Red-breasted Nuthatch (*Sitta canadensis*)		7.5 years	10	about 0.2-10 ha
			Ruby-crowned Kinglet (*Regulus calendula*)		5.6 years	7	
			Townsend's Warbler (*Dendroica townsendi*)		9.7 years	9	
	Ground Herbivore	Avian species that feed primarily on plant material and forage on the ground.	Chipping Sparrow (*Spizella passerina*)	969	2 to 9.75 years		
			Common Redpoll (*Carduelis flammea*)	3	10.7 years	13	
			Pine Siskin (*Carduelis pinus*)	1213	11 years	15	
			Spruce Grouse (*Falcipennis canadensis*)	16	13 years	492	highly variable; ranging from 6-160 ha
			Mourning Dove (*Zenaida macroura*)	24	5 to 10 years	123	
			Ruffed Grouse (*Bonasa umbellus*)	148	11 years; about 55% die in winter	621	varies; range on average about 6-20 ha
	Aquatic Invertivore	Avian species that forage in along streams and ponds probing into sediments.	American Dipper (*Cinclus mexicanus*)	20	7.2 years	61	
			Bank Swallow (*Riparia riparia*)	8	most animals do not live more than 4 years	15	
			Bufflehead (Bucephala albeola)	5	18.7 years	473	
			Marsh Wren (*Cistothorus palustris*)	7		12	
			Rufous Hummingbird (*Selasphorus rufus*)	49	8.9 years	3	
			Spotted Sandpiper (*Actitis macularius*)	29	12 years	40	
	Aquatic Herbivore/Omnivore	Avian species that feed on aquatic vegetation and sometimes aquatic invertebrates	American Coot (*Fulica americana*)	9	22.3 years	724	
			American Wigeon (*Anas americana*)	5	21.3 years	792	
			Blue-winged Teal (*Anas discors*)	6	23.2 years	409	
			Green-winged Teal (*Anas crecca*)	6	27.1 years	364	
			Mallard (*Anas platyrhynchos*)	34	29.1 years	1082	range 66 hectares to 760 hectares

[1]Number of occurrences in Lincoln, County Montana

[2]Montana Field Guide http://fieldguide.mt.gov/default.aspx

[3]AnAge: The Animal Ageing Database http://genomics.senescence.info/species/

Table 8-1
Sample Containers, Preservation and Handling Requirements, and Holding Times

Sediment Samples

Container Description	Analyses	Method	Preservation and Handling	Extraction/Analysis Holding Times
8-oz glass jar	TAL Metals + Boron	EPA 6010/6020	Cool 4°C	180 days
500 g in Ziploc bag (soil) or plastic jar (sediment)	Asbestos	PLM-Grav: SRC-LIBBY-01 (Rev. 2) PLM-VE: SRC-LIBBY-03 (Rev. 2)	None	None
8-oz glass jar	*[Archive sample]*		Cool 4°C	--
2-1 liter plastic jars	Toxicity Testing	EPA Method 100.4 EPA Method 100.3	Cool 4°C	6 months

(a) CLP analyte list
(b) with Libby-specific modifications

Organic Debris (Duff) Samples

Container Description	Analyses	Method	Preservation and Handling	Extraction/Analysis Holding Times
500 g in Ziploc bag	Asbestos	TEM-ISO10312 (a)	None	None
8-oz glass jar	*[Archive sample]*		Cool 4°C	--

(a) With Libby specific modifications

Tissue Samples

Container Description	Analyses	Method	Preservation and Handling	Extraction/Analysis Holding Times
Wide-mouthed screw top plastic jars	Asbestos	TEM-ISO10312 (a)	None	None
Wide-mouthed screw top plastic jars	*Histopathology*		10% buffered formalin	None

(a) With Libby specific modifications

Table 9-1
List of Non-Asbestsos Analyse Required for Sediment in Phase IIC

			Cations		Sediment quality parameters		
			TAL Metals		pH	Moisture	OC
Sample	**Reach**	**Station**	**SW6020**	**SW6010B**	**ASAM10-3.2**	**SW3550A**	**Leco**
1	Upper Rainy Creek	URC-1					
2		URC-1A					
3		URC-2	X	X	X	X	X
4	Lower Rainy Creek	LRC-1	X	X	X	X	X
5		LRC-2					
6		LRC-3	X	X	X	X	X
7		LRC-4					
8		LRC-5	X	X	X	X	X
9		LRC-6					
10	Tailings impoundment	TP					
11		UTP					
12		TP-TOE1					
13		TP-TOE2					
14	Mill pond	MP					
15	Fleetwood Creek	FC-1					
16		FC-Pond	X	X	X	X	X
17		FC-2	X	X	X	X	X
18	Carney Creek	CC-1	X	X	X	X	X
19		CC-Pond					
20		CC-2					
21	Reference		X	X	X	X	X

x = Sample analyzed

Table 10-1
Summary of Field Quality Control Samples

Field QC Sample Type	Applicable Sample Media	Minimum Collection Frequency	Analyses to be Performed	Acceptance Criteria	Corrective Action
Field Blank	Water	1 per 10 field samples (10%)	TEM	No LA structures detected	Assign qualifier to analyte(s) in field samples associated with field blank (same day, same team)
			Metals	< ½ PQL for all target analytes	
	Solid Media				
Equipment Rinsate Blank	Water	1 per sampling team per day	TEM	No LA structures detected	Assign qualifier to analyte(s) in field samples associated with field blank (same day, same team)
			Metals	< ½ PQL for all target analytes	
	Solid Media		TEM	No LA structures detected	
			Metals	< ½ PQL for all target analytes	
Field Duplicate	Water	1 per 10 field samples (10%)	TEM	< 5% statistically different	Assign qualifier to analyte(s) in parent field sample
			Same analyte list as original sample	20% RPD for target analytes	
	Sediment	1 per 10 field samples (10%)	PLM-VE	*[Not applicable for field duplicates]*	*[Not applicable for field duplicates]*
			Same analyte list as original sample		
Performance Evaluation (PE)					Assign qualifier to field samples for analyte(s) outside of acceptance criteria
	Solid Media	4 PE samples	PLM-VE	80% concordance	
		3 PE samples	Inorganic and organic analytes	(b)	

(a) depending on analyses requested with associated samples
(b) meet analyte-specific criteria specified by QATS certification program

Table 10-2. Summary of Laboratory Quality Control Measures, by Analysis

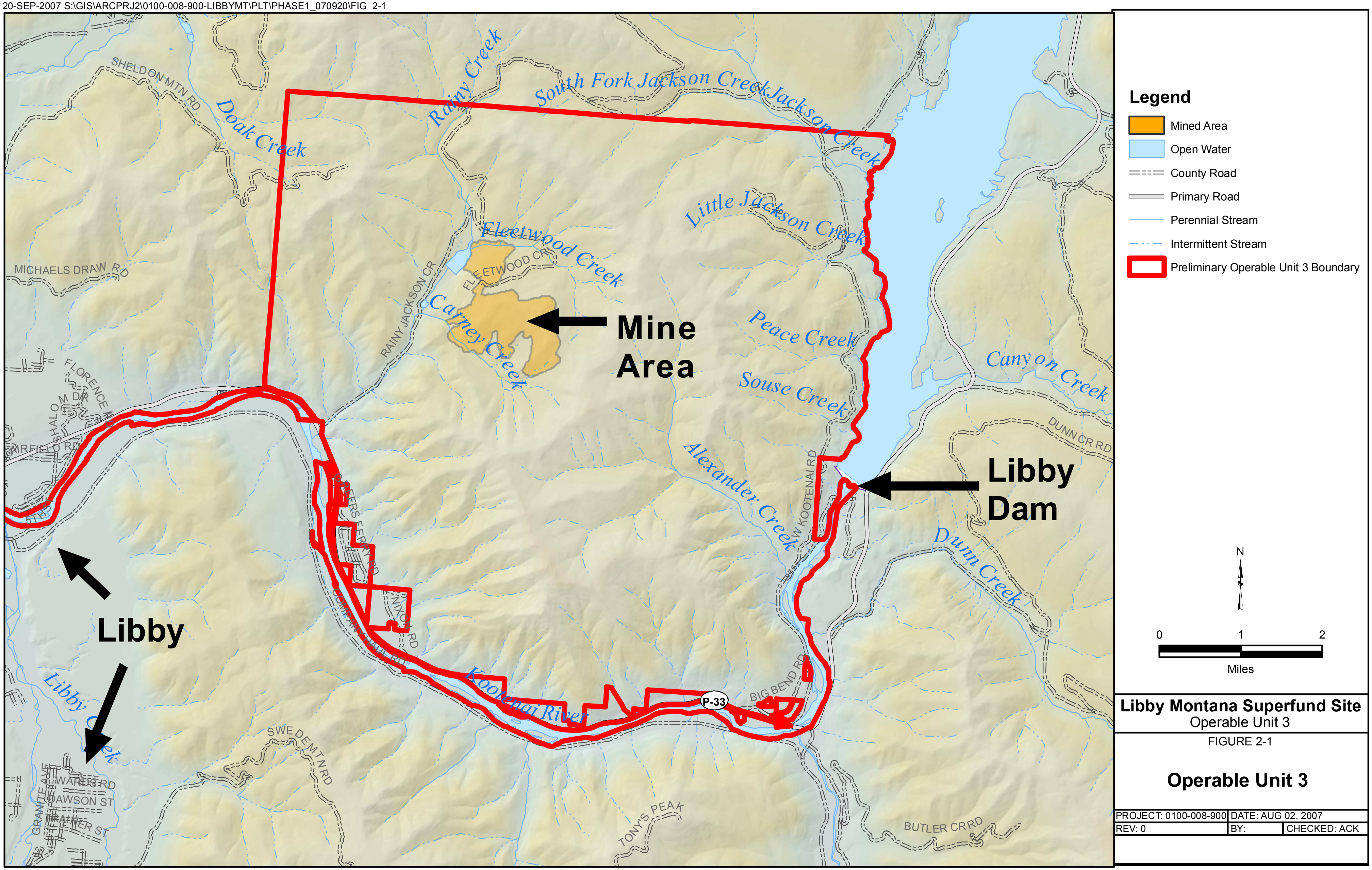
Analytical Method[a]	QC Element	Frequency	Acceptance Criteria	Corrective Action
ICP Metals SW-846 6010B (and EPA 200.7 for aqueous samples)	Initial calibration (1 point + blank minimum)	Daily prior to analysis	Correlation coefficient (r) ≥0.995	• Recalibrate
	Interference check standard (ICS)	Beginning and end of each analytical run	Results +/- 20% of true value	• Terminate analysis • Recalibrate instrument • Reanalyze all samples back to last acceptable ICS
	Initial calibration verification (ICV)	After calibration, prior to sample analysis	Results <10% from calibration standard	• Reanalyze ICV • Recalibrate, if ICV still out
	Continuing calibration verification (CCV)	Every 10 samples and end of analytical sequence	Results < 10% from calibration standard	• Reanalyze affected samples back to the last acceptable CCV
	Calibration blank - Initial calibration blank (ICB), Continuing calibration blank (CCB)	After initial calibration verification, each subsequent calibration verification, and at the end of the run	<3x the Method detection limit (MDL)	• Reanalyze blank • Clean system • Reanalyze all samples back to last acceptable blank
	Method blank	1 per preparation batch (≤20 samples)	< ½ x Practical quantitation limit (PQL)	• Reanalyze method blank. • If fails, analyze a calibration blank • Reprep/reanalyze analytical batch as appropriate
	Matrix spike (MS)	1 per preparation batch (≤20 samples)	% Recovery +/-25% of actual value	• Assess data (4 x rule) • If LCS recoveries are within acceptance criteria, then matrix interference may be suspected • Reanalyze reprep once if matrix is not a factor • Narrate all outliers
	Matrix spike duplicate (MSD)	1 per preparation batch (≤20 samples)	RPD <20%	• Same as MS
	Laboratory Control Sample (LCS)	1 per preparation batch (≤20 samples)	% Recovery +/- 20% of actual value	• Reanalyze LCS • Reprep/reanalyze LCS and affected samples • Narrate all outliers
ICP-MS Metals SW-846 6020 (and EPA 200.8 for aqueous samples)	Mass calibration and resolution check (4 replicates)	Daily prior to analysis	Mass calibration < 0.1 amu; resolution <0.9 amu at 10% peak height; RSD <5%	• Recalibrate
	Initial multipoint calibration (1 point + blank minimum); average of 3 integrations	Daily prior to analysis	None	• None

Table 10-2. Summary of Laboratory Quality Control Measures, by Analysis

Analytical Method[a]	QC Element	Frequency	Acceptance Criteria	Corrective Action
	Initial calibration verification (ICV); mid-level standard second source	After calibration, prior to sample analysis	± 10% from true value	• Reanalyze ICV • Recalibrate, if ICV still out
	Continuing calibration verification (CCV)	Every 10 samples and end of run sequence	± 10% from true value	• Reanalyze affected samples back to the last acceptable CCV
ICP-MS Metals SW-846 6020 (and EPA 200.8 for aqueous samples)	Interference check solution	At beginning of analytical sequence or once every 12 hours, whichever is more frequent	Recoveries +/- 20% of theoretical value	• Internal QC review only; flag data to indicate interference
	Internal Standards	Every CCV, ICB/CCB	Recoveries +/- 20% of initial calibration	• Recalibrate and verify calibration • Reanalyze affected samples
		Every sample	Recoveries 30-120% for samples	• Dilute sample 5x and reanalyze • Repeat until within limits
	Calibration blank Initial calibration blank (ICB) Continuing calibration blank (CCB)	After initial calibration and each subsequent calibration verification	< 3 x Method detection limit (MDL)	• Reanalyze blank • Clean system if still out • Reanalyze affected samples back to the last acceptable CCB
	Method blank	1 per preparation batch (≤ 20 samples)	< ½ x PQL	• Reanalyze method blank. • If fails, analyze a calibration blank • Reprep/reanalyze analytical batch as appropriate
	Matrix spike (MS)	1 per preparation batch (≤ 20 samples)	% Recovery +/- 25% of true value	• Assess data • Reanalyze MS if matrix is not a factor
	Matrix spike duplicate (MSD) or Matrix duplicate (MD)	1 per preparation batch (≤ 20 samples)	RPD < 20% (for values > 100 x MDL)	• Same as MS
	Post-digestion spike addition	As necessary to assess matrix interference	% Recovery +/- 25% of actual value	• Perform dilution test • Or, perform method of standard addition
	Dilution test	1 per 20 samples	% Recovery +/- 10% of true value	• Use method of standards addition
	Laboratory control sample (LCS)	1 per preparation batch (≤ 0 samples)	%Recovery within +/- 20% of true value	• Reanalyze LCS • Reprep/reanalyze LCS and affected samples • Narrate all outliers

EICP Extracted ion current profile
QC Quality control
RF Response factor
RSD Relative standard deviation

20-SEP-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE1_070920\FIG 2-1



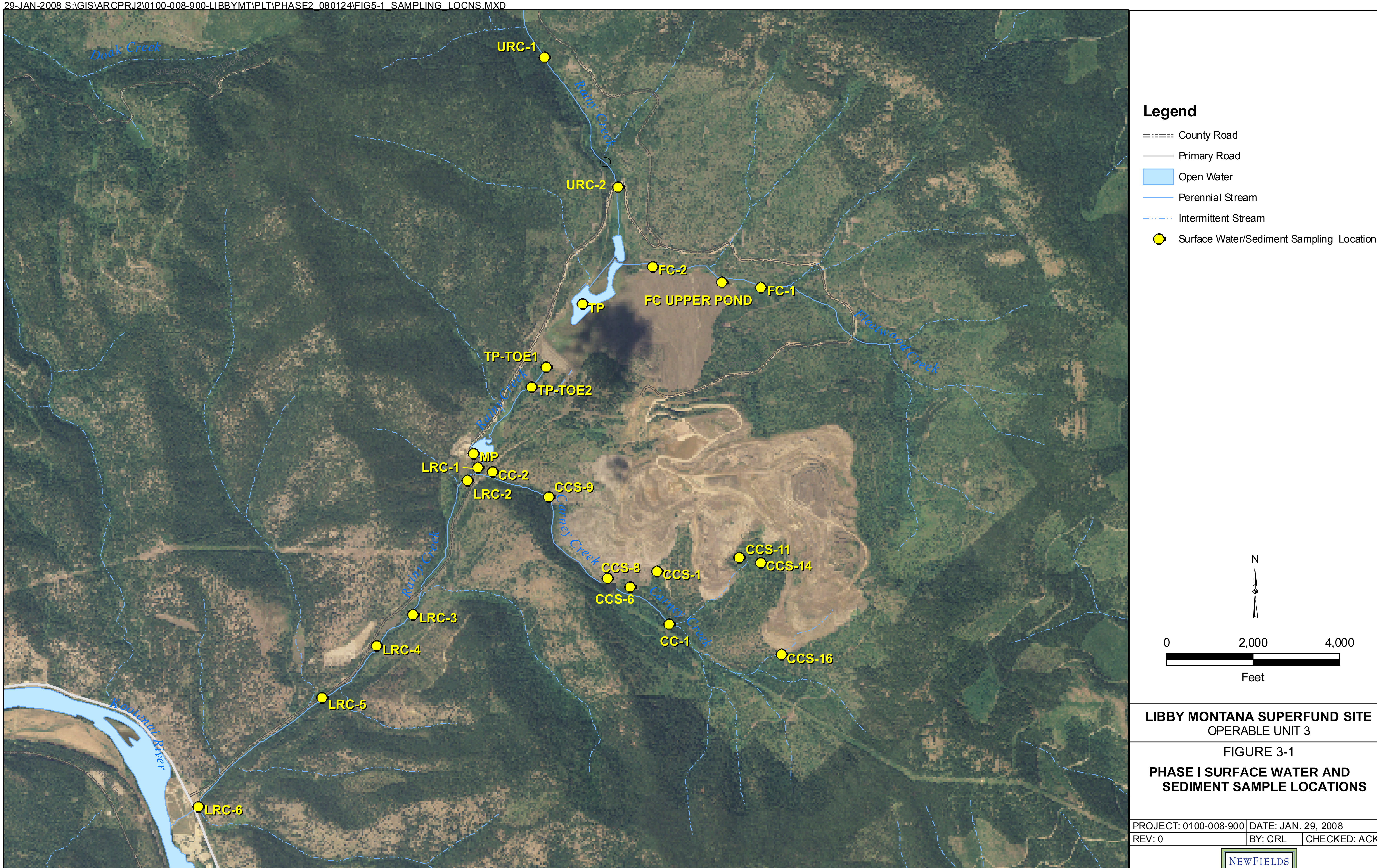
Libby Montana Superfund Site
Operable Unit 3

FIGURE 2-1

Operable Unit 3

PROJECT: 0100-008-900	DATE: AUG 02, 2007	
REV: 0	BY:	CHECKED: ACK

29-JAN-2008 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE2_080124\FIG5-1_SAMPLING_LOCNS.MXD



LIBBY MONTANA SUPERFUND SITE
OPERABLE UNIT 3

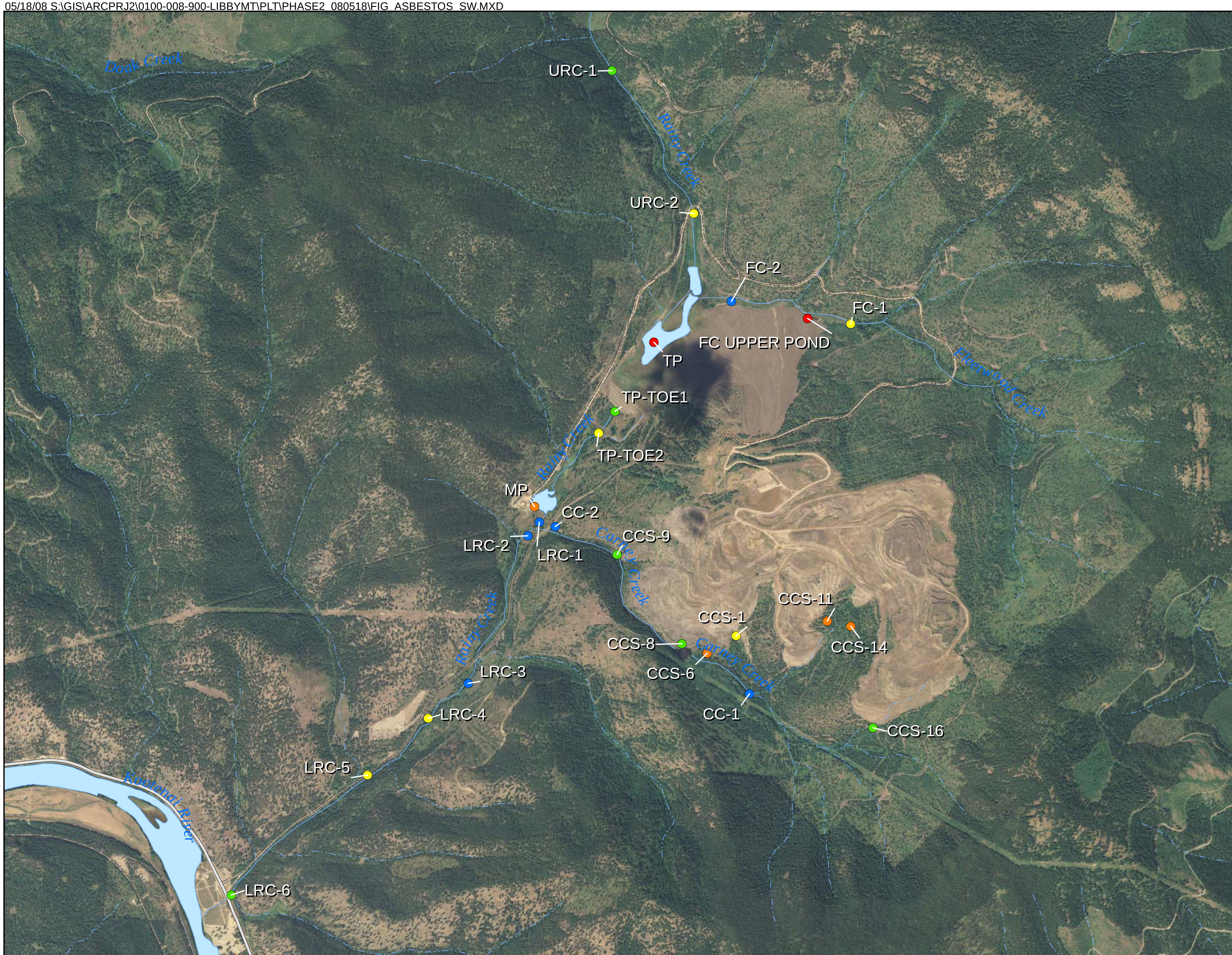
FIGURE 3-1

PHASE I SURFACE WATER AND SEDIMENT SAMPLE LOCATIONS

PROJECT: 0100-008-900	DATE: JAN. 29, 2008	
REV: 0	BY: CRL	CHECKED: ACK

NEWFIELDS

05/18/08 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE2_080518\FIG_ASBESTOS_SW.MXD



Legend

- County Road
- Primary Road
- Open Water
- Perennial Stream
- Intermittent Stream

Asbestos in Surface Water (Total LA)

- Non Detect
- > ND - 1 MFL
- 1 - 10 MFL
- 10 - 100 MFL
- > 100 MFL

N

0 2,000 4,000

Feet

LIBBY MONTANA SUPERFUND SITE

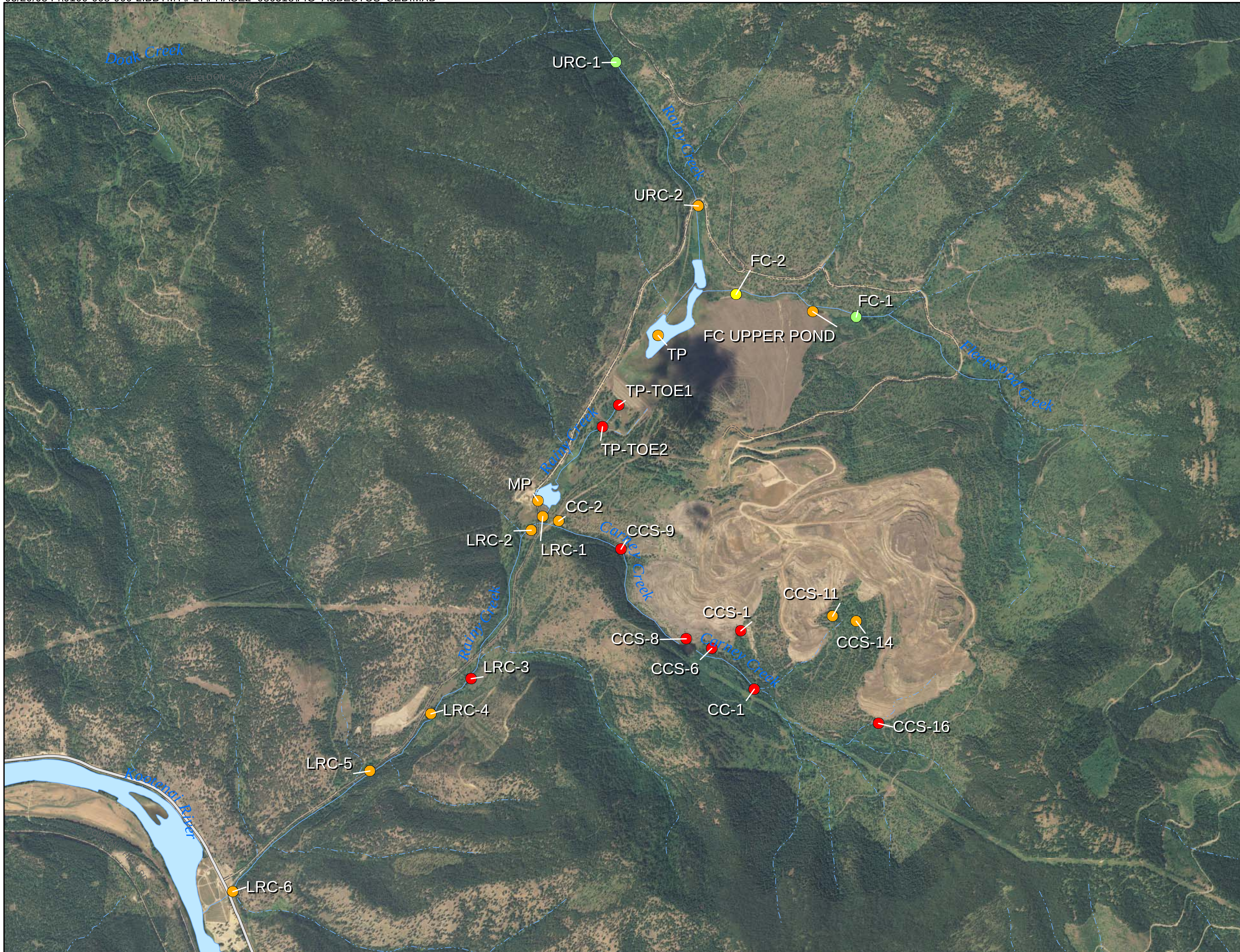
OPERABLE UNIT 3

FIGURE 3-2

ASBESTOS LEVELS IN SURFACE WATER

PROJECT: 0100-008-900	MAY 18, 2008	
REV: 0	BY: VFS	CHECKED: KJT

NEWFIELDS



Legend

Asbestos Levels in Sediment (MFLA % Fine)

- ND
- TR
- < 1%
- 2 - 6%
- County Road
- Primary Road
- Open Water
- Perennial Stream
- Intermittent Stream

N

0 2,000 4,000

Feet

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

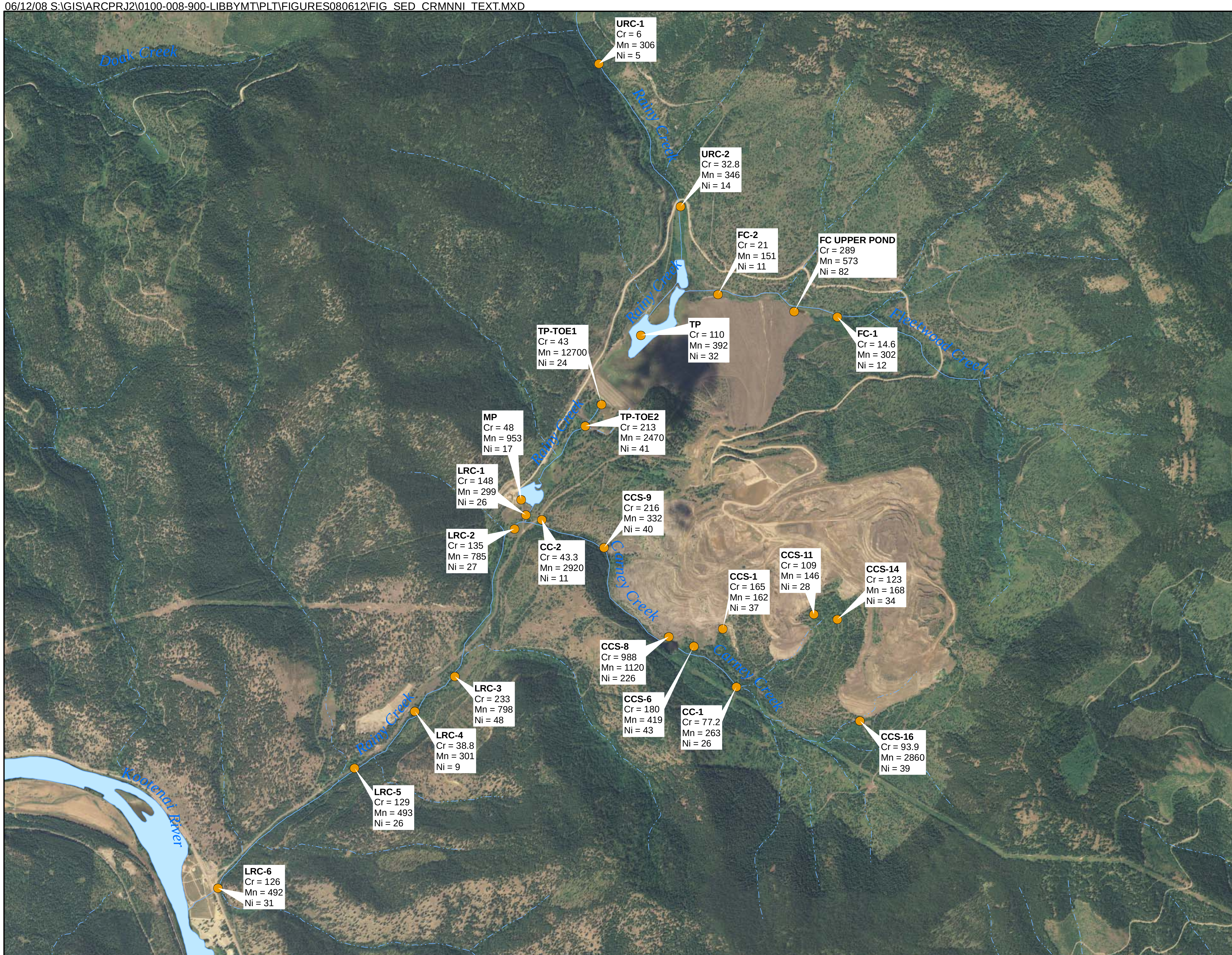
FIGURE 3-3

ASBESTOS LEVELS IN SEDIMENT

PROJECT: 0100-008-900	MAY 20, 2008	
REV: 0	BY: VFS	CHECKED: KJT

NEWFIELDS

06/12/08 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\FIGURES080612\FIG_SED_CRMNNI_TEXT.MXD



Legend

Sediment Sample Location

N

0 0.25 0.5

Miles

LIBBY MONTANA SUPERFUND SITE

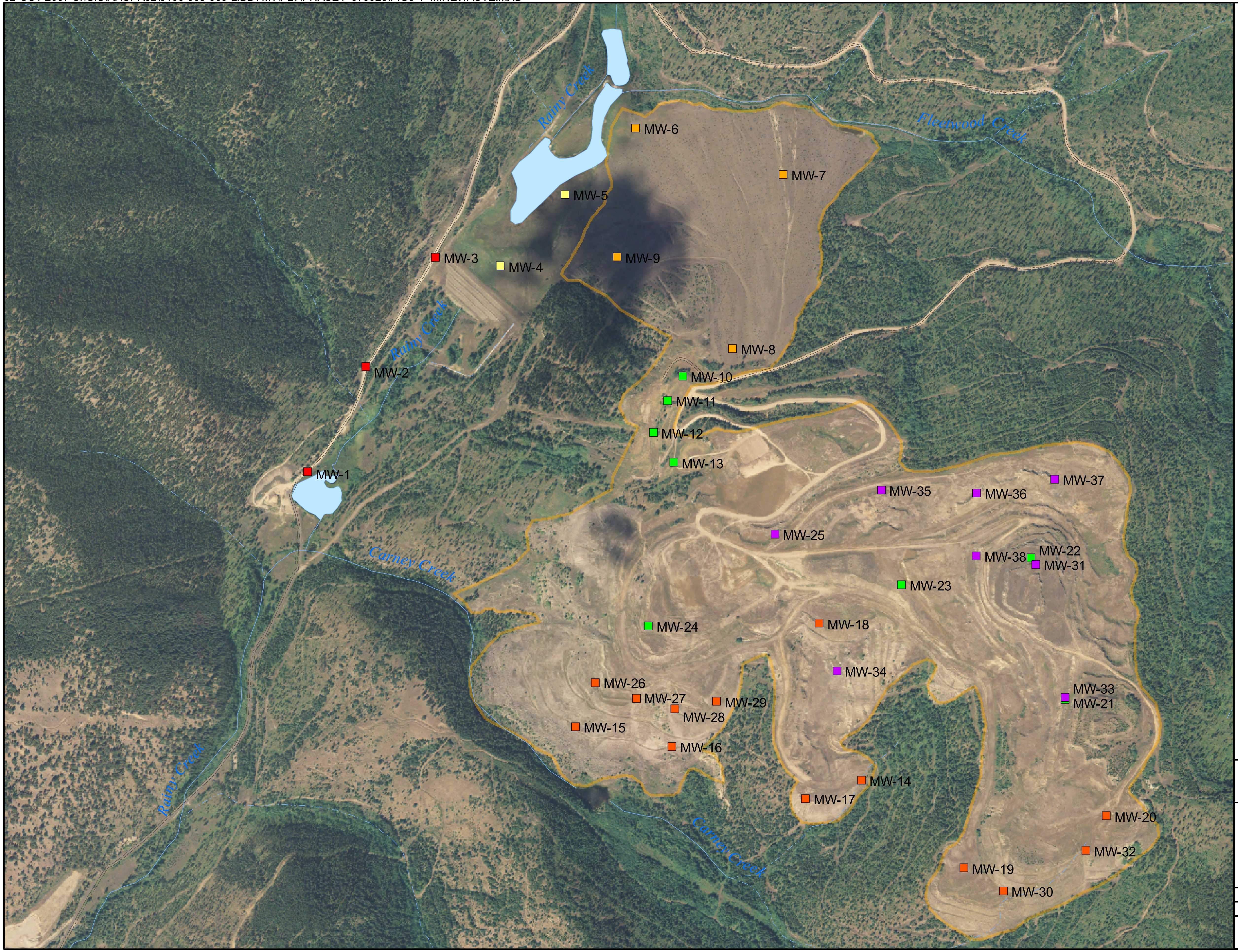
OPERABLE UNIT 3

FIGURE 3-4

CHROMIUM, MANGANESE, AND NICKEL CONCENTRATIONS IN SEDIMENTS

PROJECT::	JUN 12, 2008	
REV:	BY:	CHECKED:

NEWFIELDS



Legend

- County Road
- Primary Road
- Open Water
- Perennial Stream
- Intermittent Stream
- Mined Area

MineWaste Sampling Location

- Waste Rock
- Cover Material
- Outcrop
- Coarse Tailings
- Tailings Impoundment
- Road

N

0 1,000 2,000

Feet

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

FIGURE 3-5

MINE WASTE SAMPLING LOCATIONS

PROJECT: 0100-008-900	DATE: OCT 3, 2007	
REV: 0	BY: CRL	CHECKED: ACK

NEWFIELDS

Legend

Asbestos in Mine Waste (MFLA % Fine)

- ND
- TR
- < 1%
- 2 - 8 %
- Open Water
- Perennial Stream
- Intermittent Stream

N

0 1,000 2,000
Feet

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

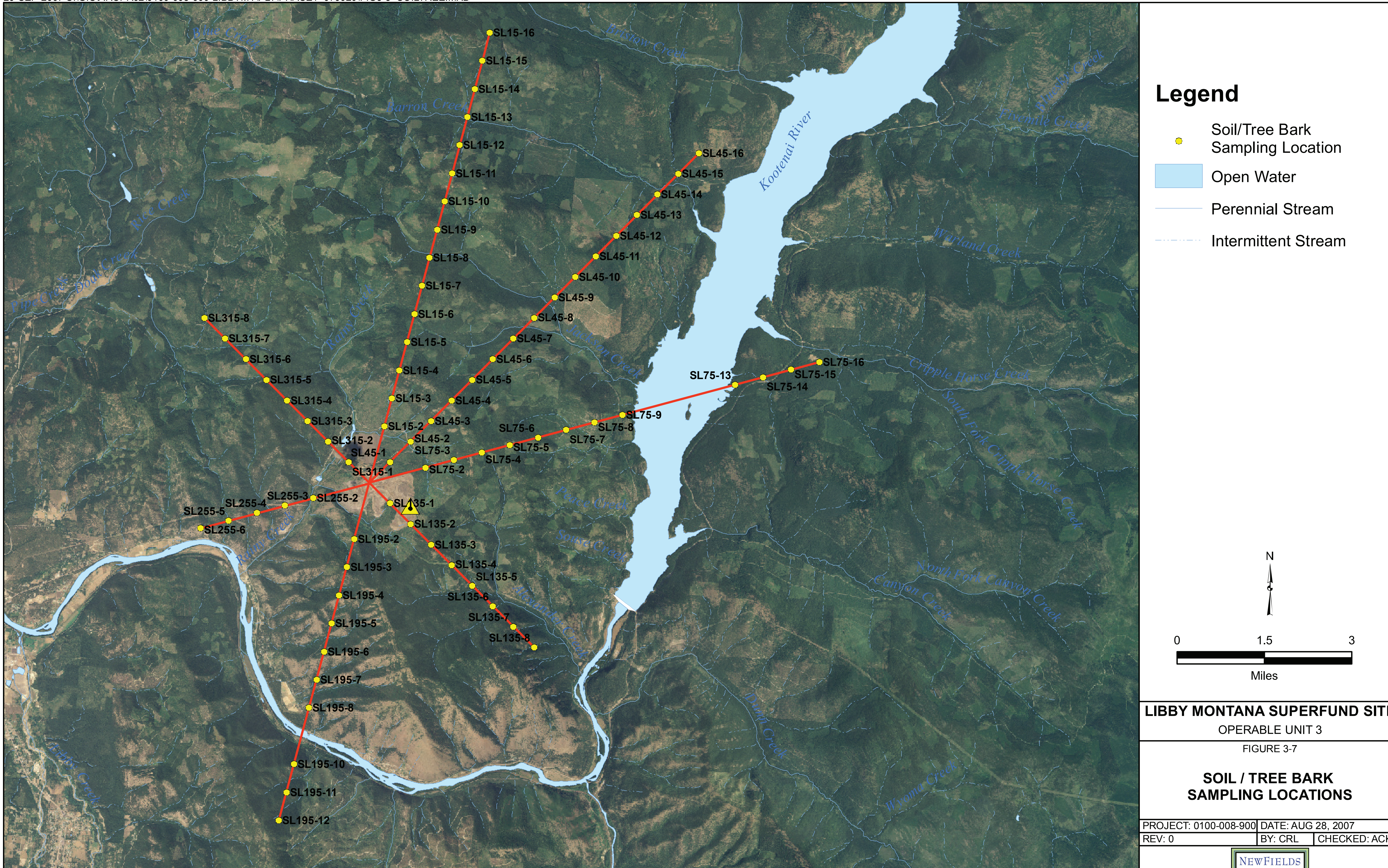
FIGURE 3-6

ASBESTOS LEVELS IN MINE WASTE

PROJECT: 0100-008-900	MAY 20, 2008
REV: 0	BY: VFS / CHK: ACK

NEWFIELDS

20-SEP-2007 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE1_070920\FIG5-3_SOILTREE.MXD



LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

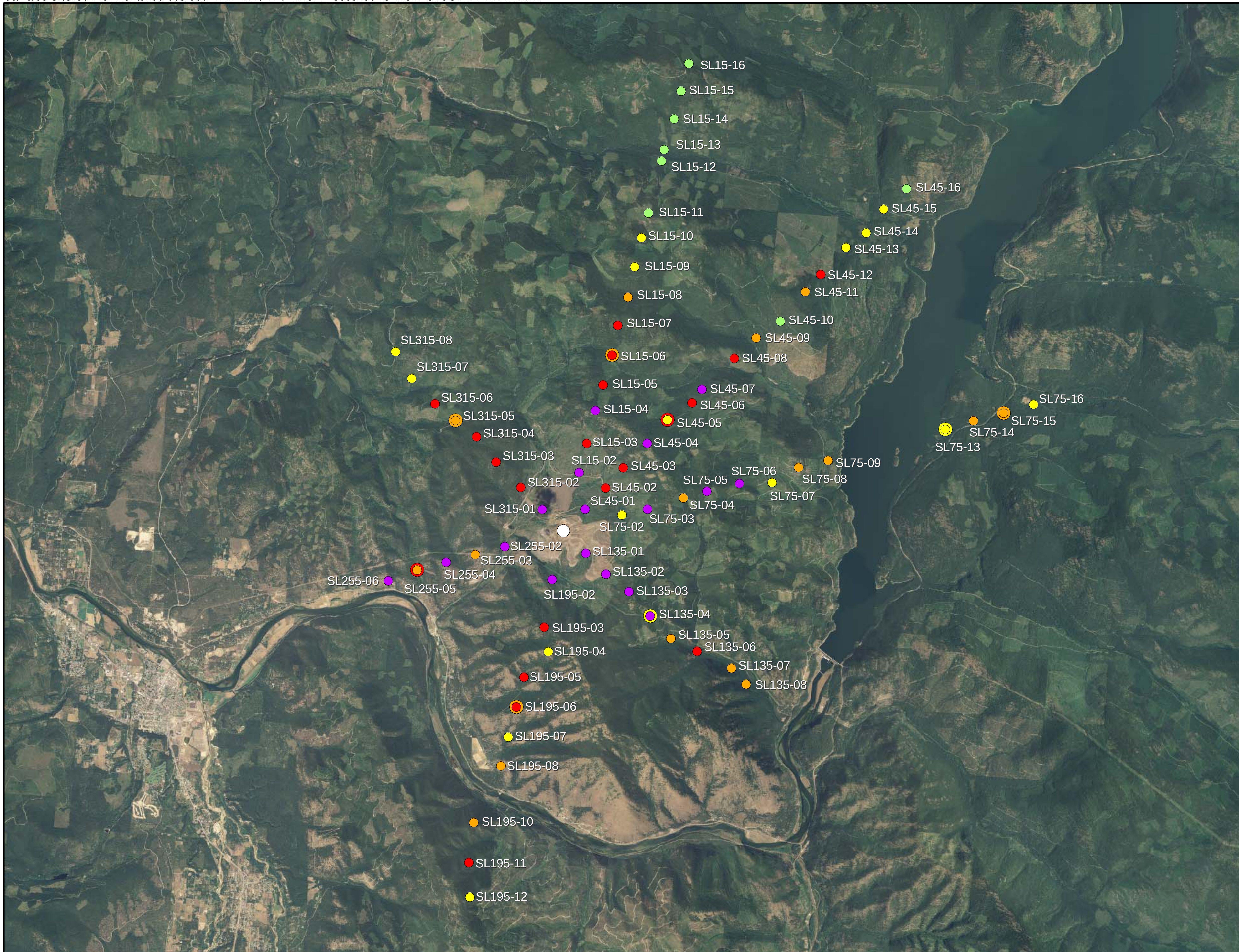
FIGURE 3-7

SOIL / TREE BARK SAMPLING LOCATIONS

PROJECT: 0100-008-900	DATE: AUG 28, 2007	
REV: 0	BY: CRL	CHECKED: ACK

NEWFIELDS

05/18/08 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE2_080518\FIG_ASBESTOSTREEBARK.MXD



Legend

Asbestos Levels in Tree Bark (TEM)

- ND
- < 0.10000 Ms/cm2
- 0.100001 - 0.50000 Ms/cm2
- 0.500001 - 2.50000 Ms/cm2
- 2.500001 - 20.00000 Ms/cm2

Duplicates of Asbestos in Tree Bark (TEM)

- ND
- < 0.1000 Ms/cm2
- 0.100001 - 0.500000 Ms/cm2
- 0.500001 - 2.500000 Ms/cm2
- 2.500001 - 20.00000 Ms/cm2
- Origin of Transects

N

0 2 4

Miles

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

FIGURE 3-8

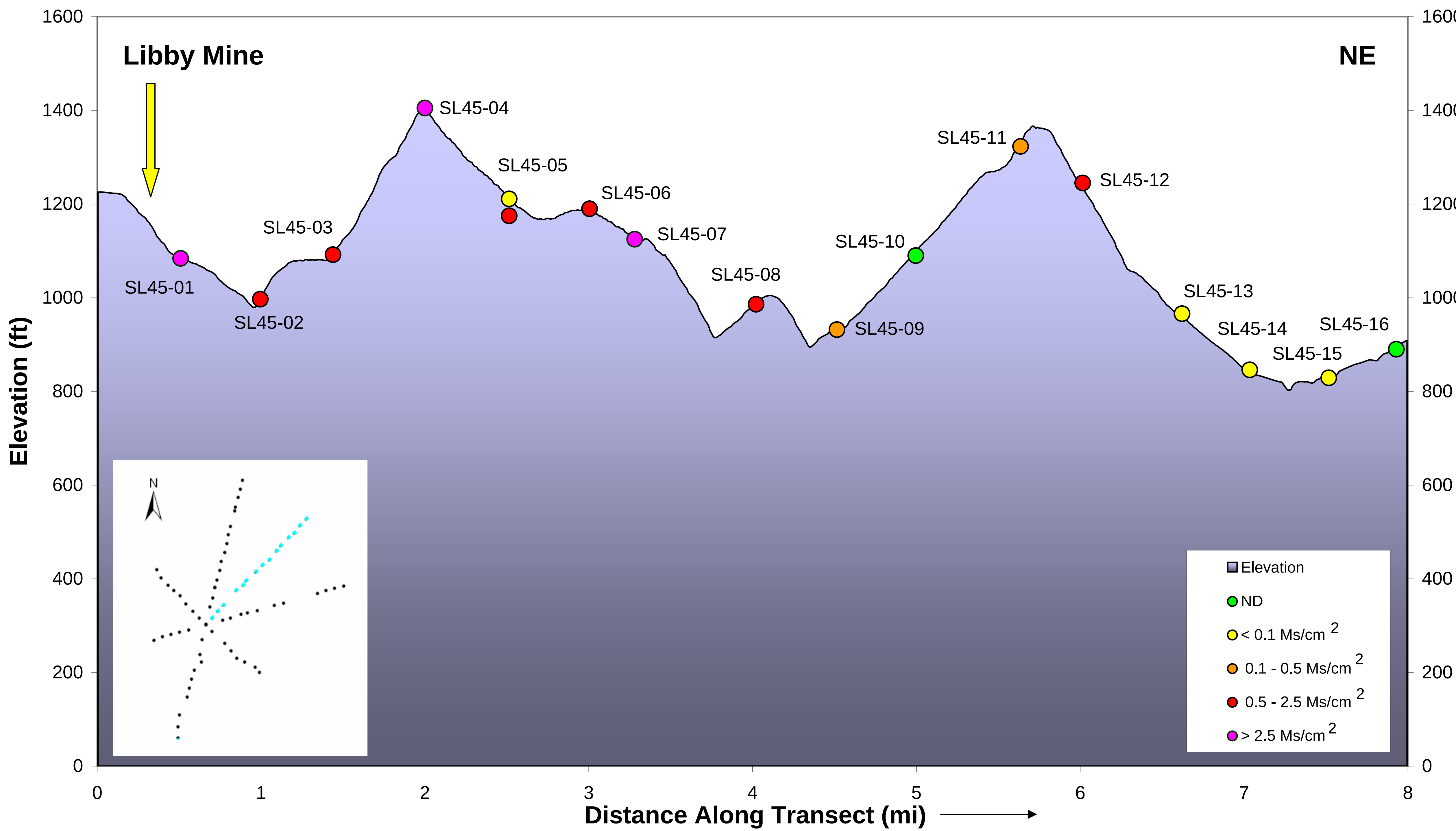
ASBESTOS LEVELS IN TREE BARK

PROJECT: 0100-008-900	MAY 18, 2008	
REV: 0	BY: VFS	CHECKED: ACK

NEWFIELDS

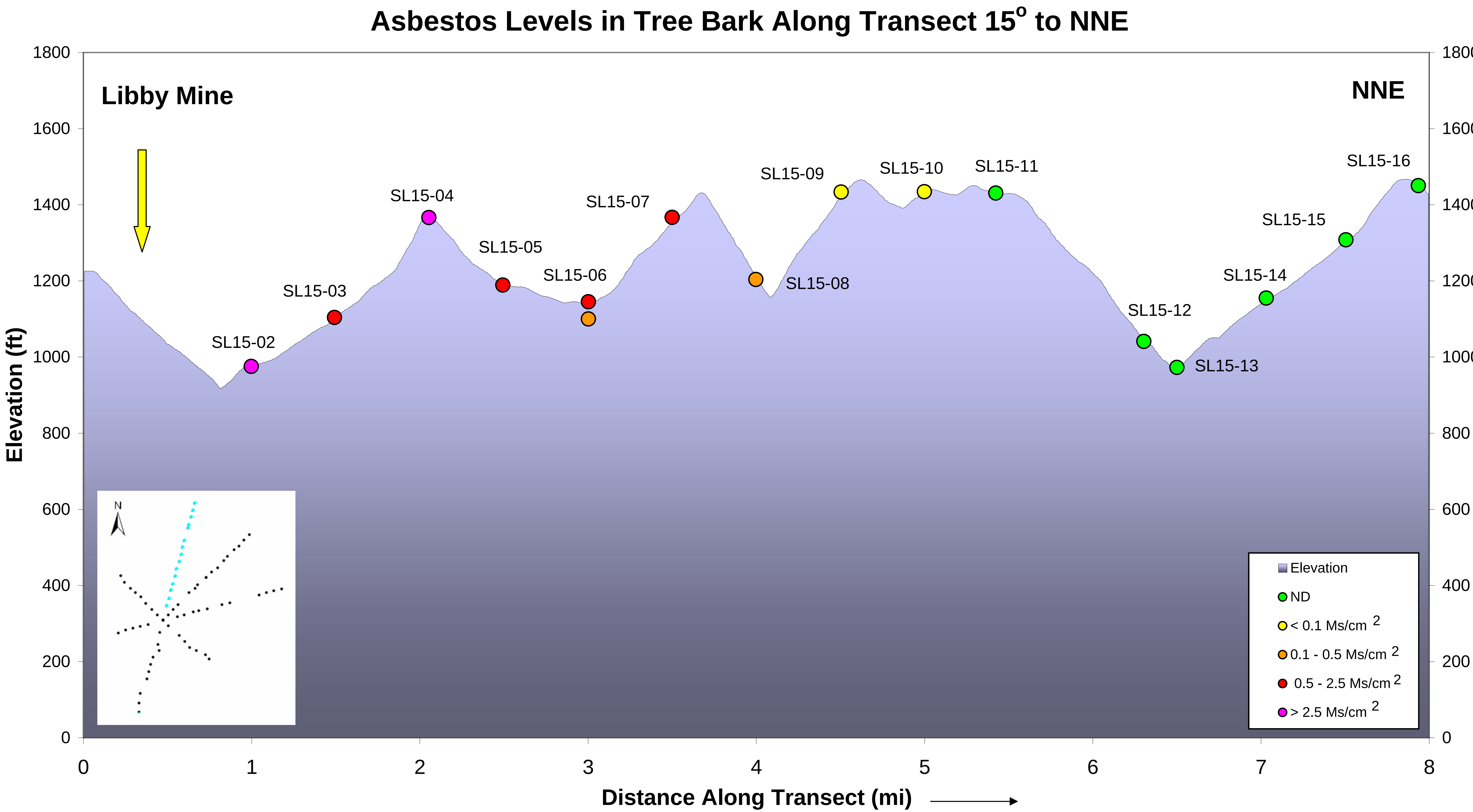
Figure 3-9

Asbestos Levels in Tree Bark Along Transect 45° to NE



Libby Montana Superfund Site - OU3
Project 0100-008-900

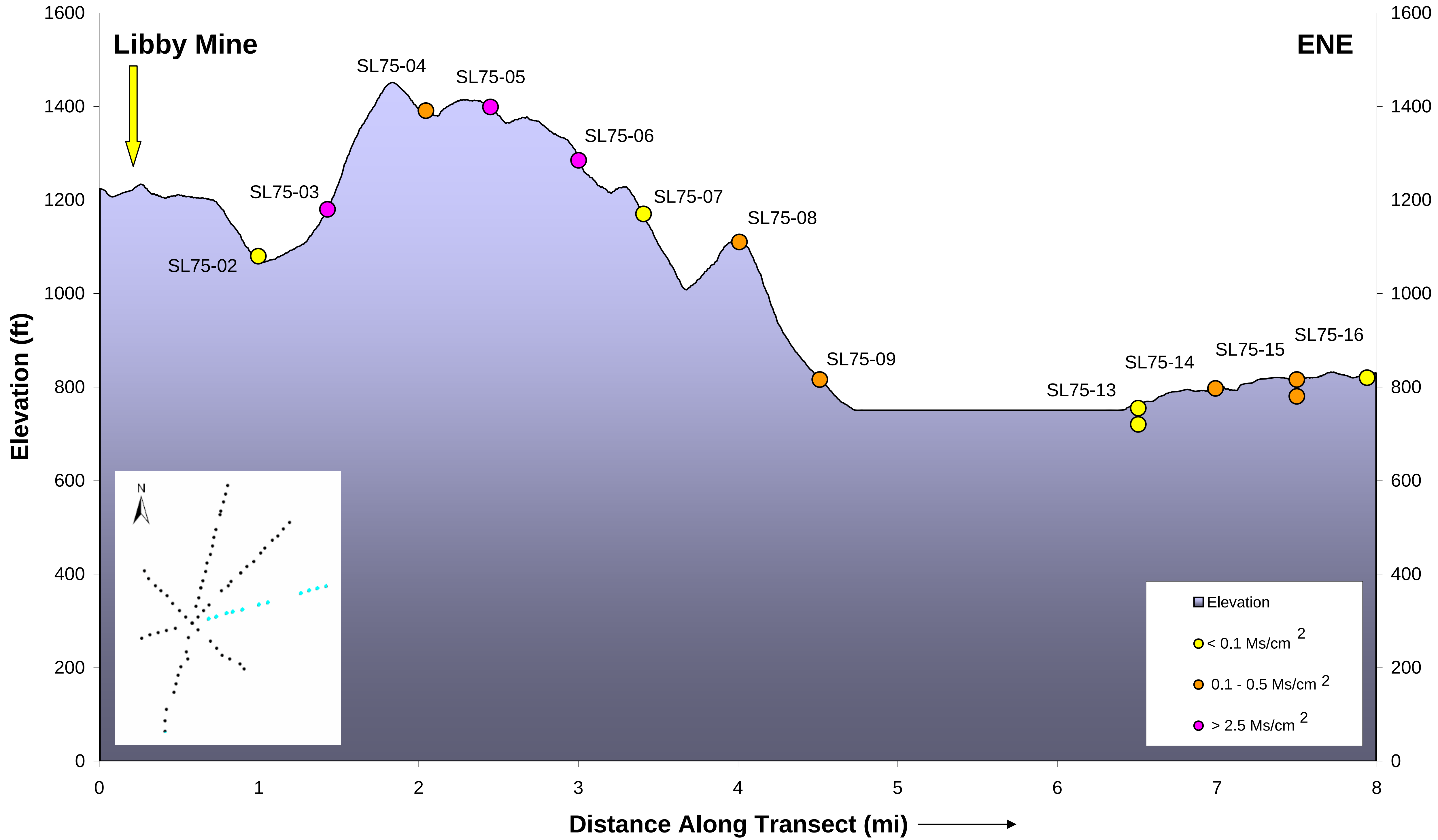
Figure 3-10



Libby Montana Superfund Site - OU3
Project 0100-008-900

Figure 3-11

Asbestos Levels in Tree Bark Along 75° Transect to ENE



Libby Montana Superfund Site - OU3
Project 0100-008-900

Figure 3-12

Asbestos Levels in Tree Bark Along Transect 195° to the SSW

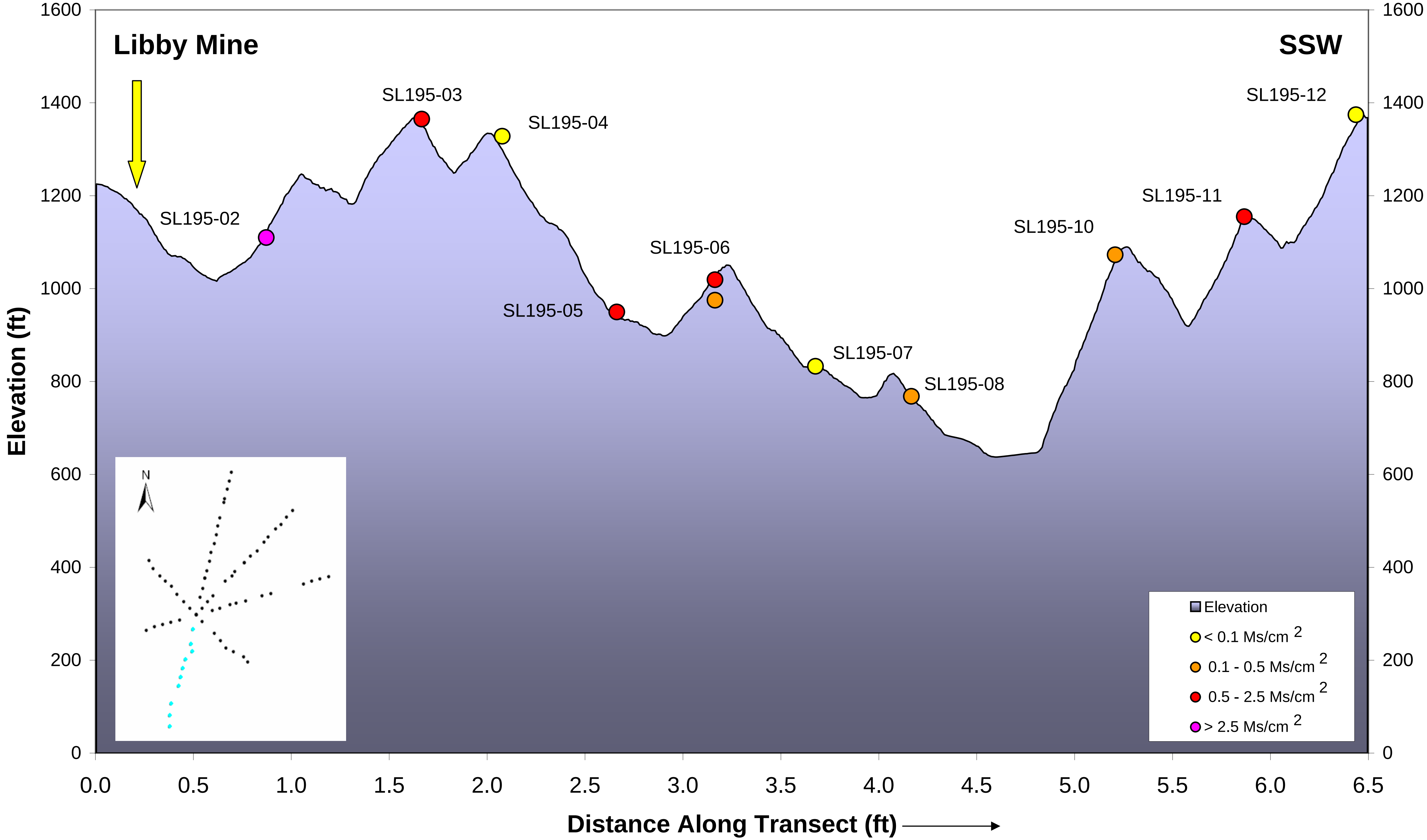
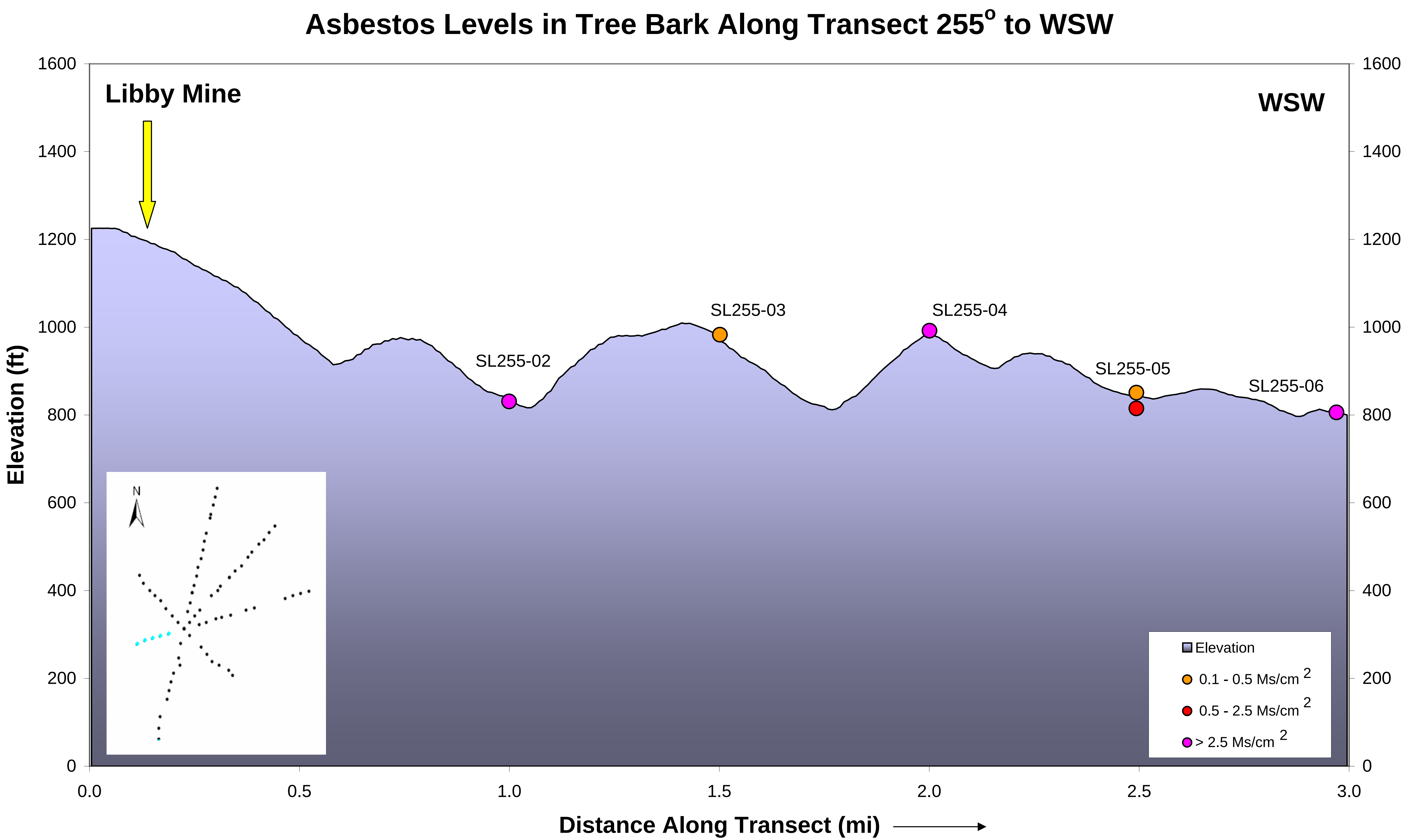


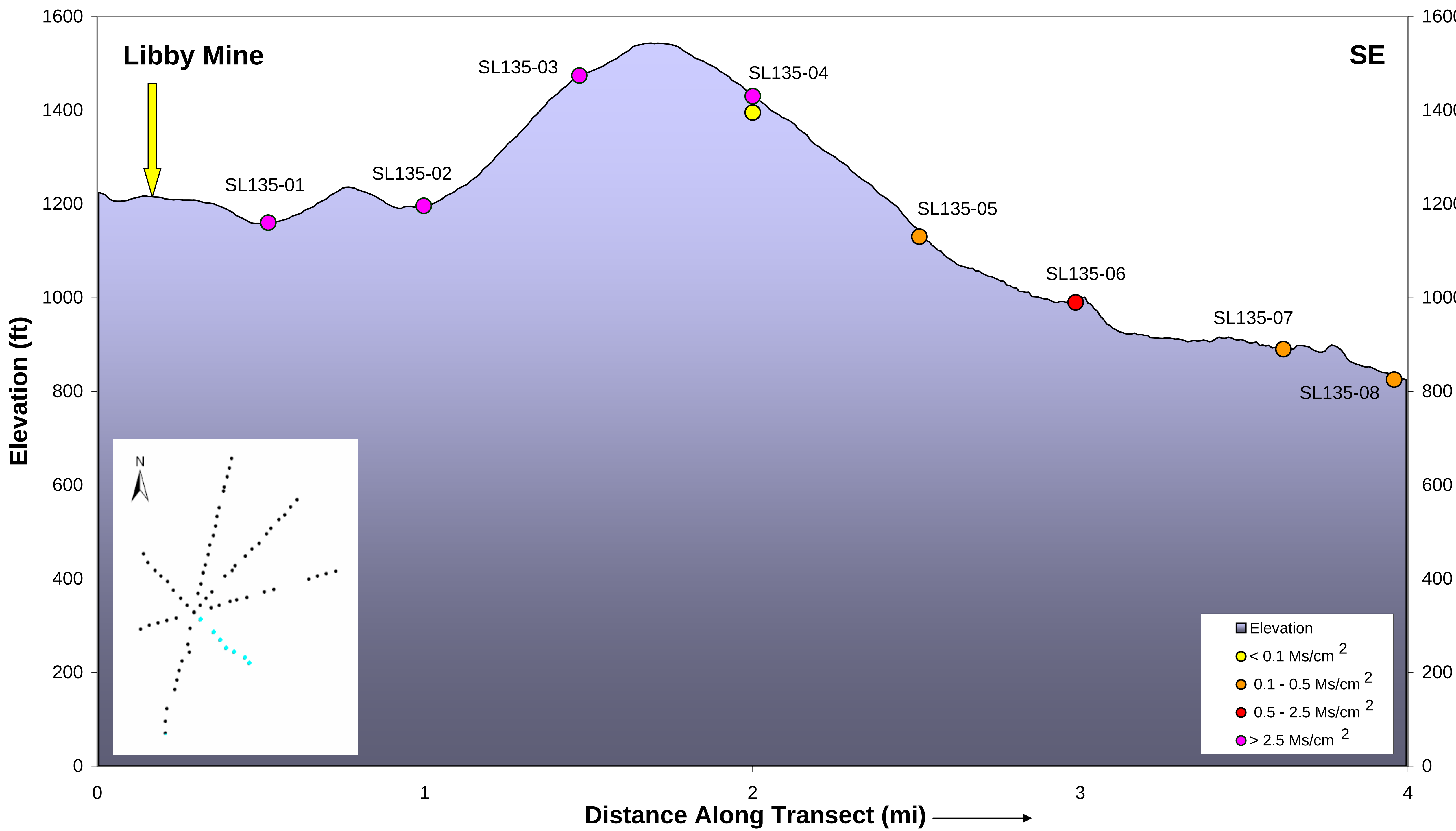
Figure 3-13


Asbestos Levels in Tree Bark Along Transect 255° to WSW
Libby Mine
WSW
SL255-02
SL255-03
SL255-04
SL255-05
SL255-06
N
Elevation (ft)
Distance Along Transect (mi)
1600
1400
1200
1000
800
600
400
200
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Elevation
0.1 - 0.5 Ms/cm 2
0.5 - 2.5 Ms/cm 2
> 2.5 Ms/cm 2

Libby Montana Superfund Site - OU3
Project 0100-008-900

Figure 3-14

Asbestos Levels in Tree Bark Along Transect 135^{o} to SE



Libby Montana Superfund Site - OU3
Project 0100-008-900

Figure 3-15

Asbestos Levels in Tree Bark Along Transect 315° to NW

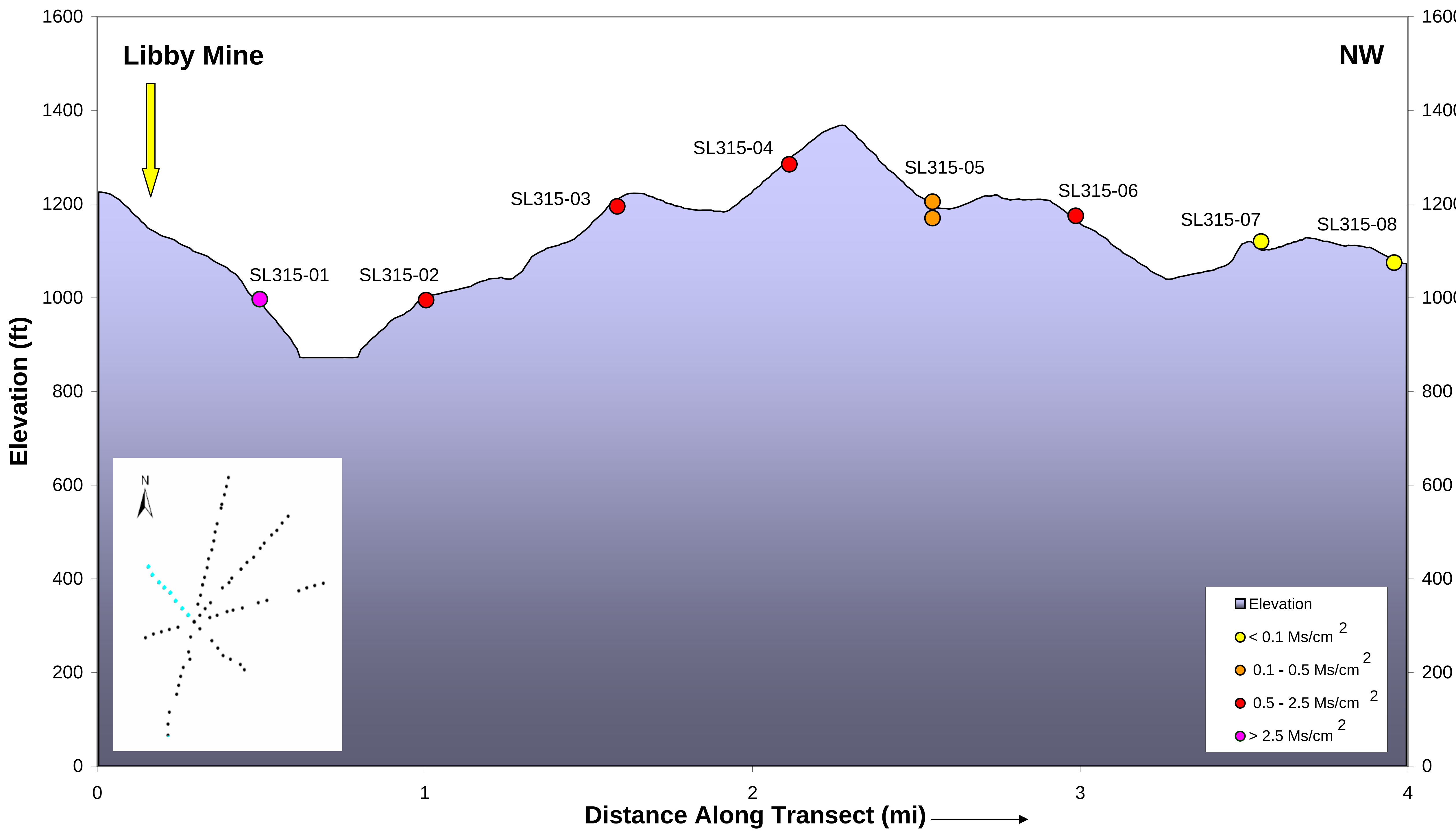
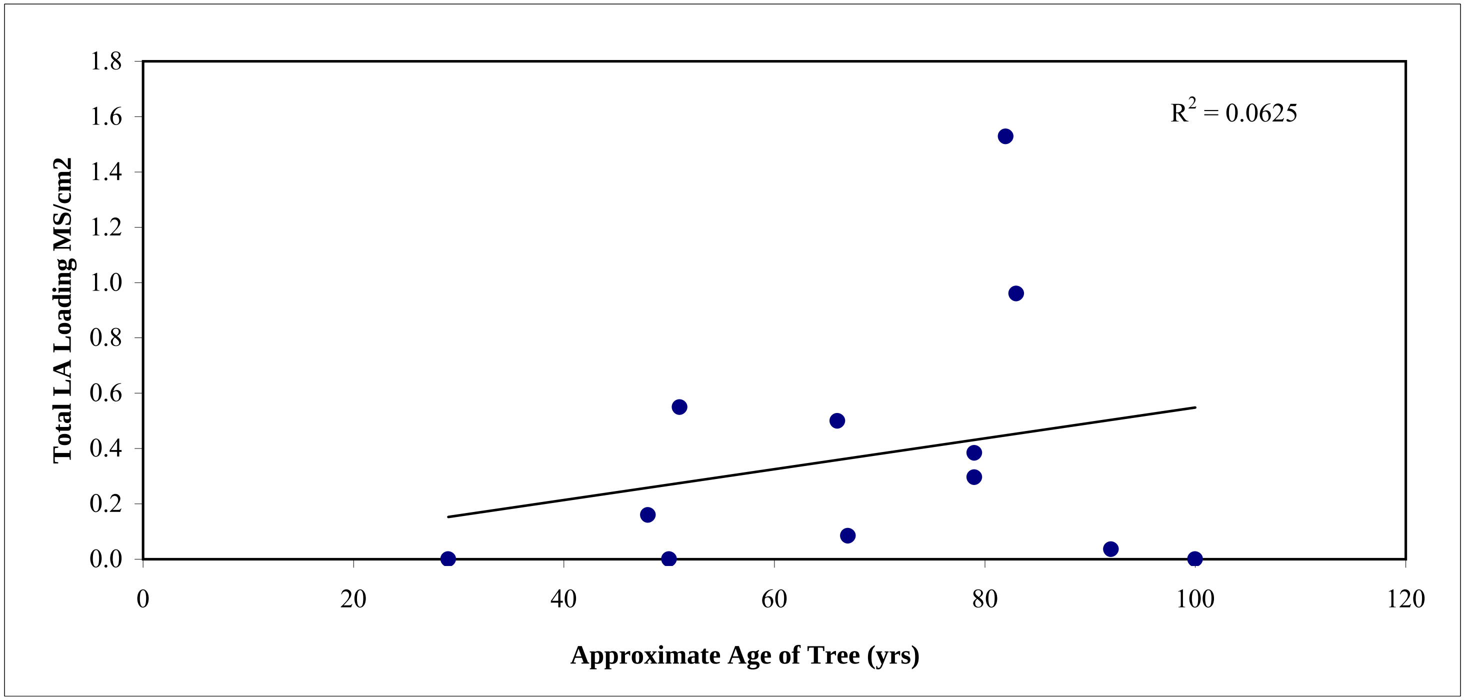
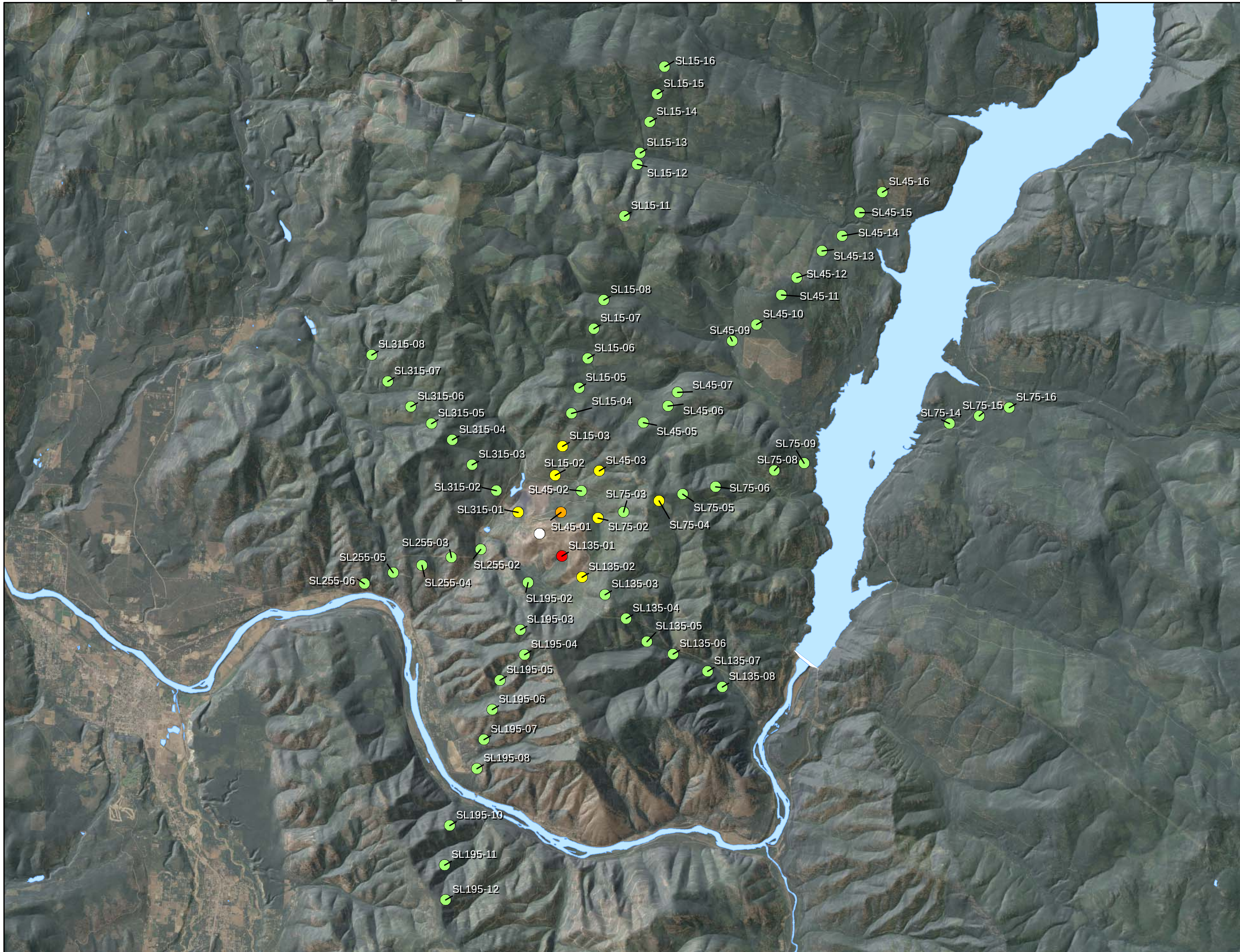


Figure 3-16. Tree Core (Age of Trees) vs. Asbestos in Tree Bark



05/18/08 S:\GIS\ARCPRJ2\0100-008-900-LIBBYMT\PLT\PHASE2_080518\FIG_ASBESTOS_SOIL.MXD



Legend

Open Water

Origin of Transects

Asbestos Levels in Soil (PLM-VE)

- ND
- TR
- <1%
- 2 - 6%

N

0 1 2

Miles

LIBBY MONTANA SUPERFUND SITE

OPERABLE UNIT 3

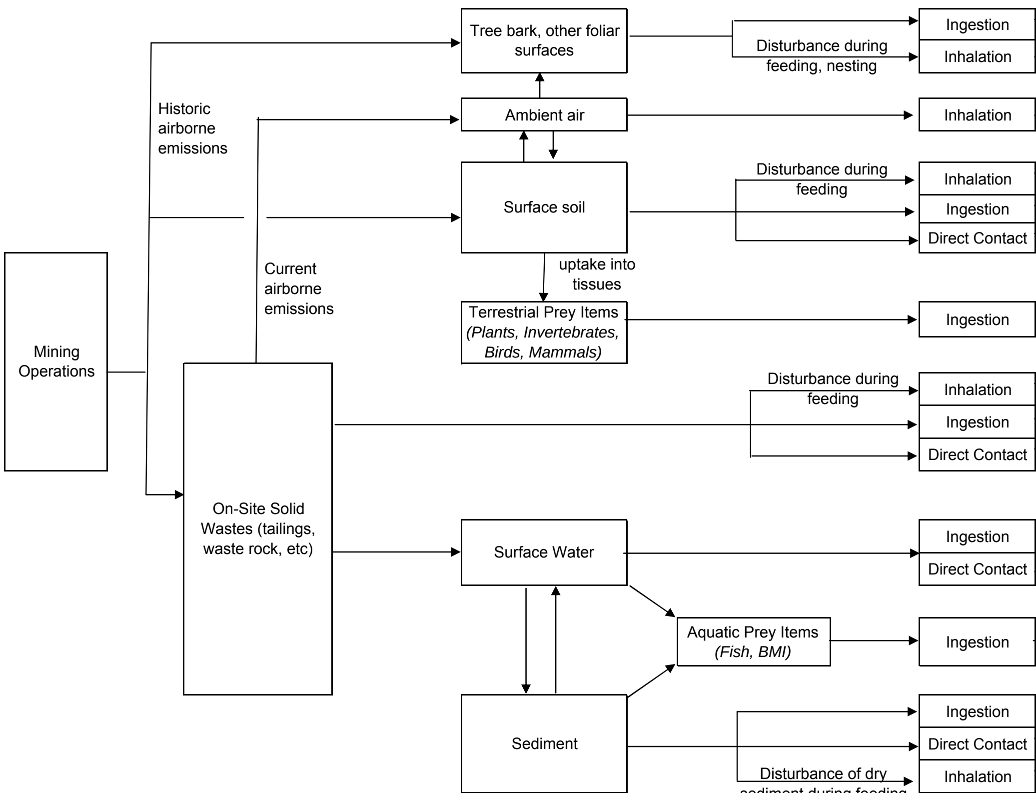
FIGURE 3-17

ASBESTOS LEVELS IN FOREST SOILS

PROJECT: 0100-008-900	MAY 18, 2008	
REV: 0	BY: VFS	CHK: ACK

NEWFIELDS

Figure 4-1. Conceptual Site Model for Exposure of Ecological Receptors to Non-Asbestos Contaminanats at OU3



		Fish	Benthic Invertebrates	Terrestrial Plant	Soil Invertebrate	Bird	Mammal	Amphibian
Tree bark, other foliar surfaces	Ingestion					O	O	
	Inhalation					O	O	
Ambient air	Inhalation					O	O	O
Surface soil	Inhalation					O	O	
	Ingestion				●	●	●	
	Direct Contact			●		O	O	
Terrestrial Prey Items	Ingestion					●	●	●
On-Site Solid Wastes	Inhalation					O	O	
	Ingestion				●	●	●	
	Direct Contact			●		O	O	
Surface Water	Ingestion	●	●			●	●	●
	Direct Contact					O	O	
Aquatic Prey Items	Ingestion	●	●			●	●	●
Sediment	Ingestion	●	●			●	●	●
	Direct Contact	●				O	O	●
	Inhalation					O	O	O

LEGEND

● Pathway is believed to be complete, and which may provide an important contribution to the total risk to the receptor.

O Pathway is believed to be complete but is unlikely to be a major contributor to the total risk to the receptor (in comparison to one or more other pathways that are evaluated).

(blank) Pathway is incomplete or believed to be negligible

Figure 4-2. Conceptual Site Model for Exposure of Ecological Receptors to Asbestos at OU3

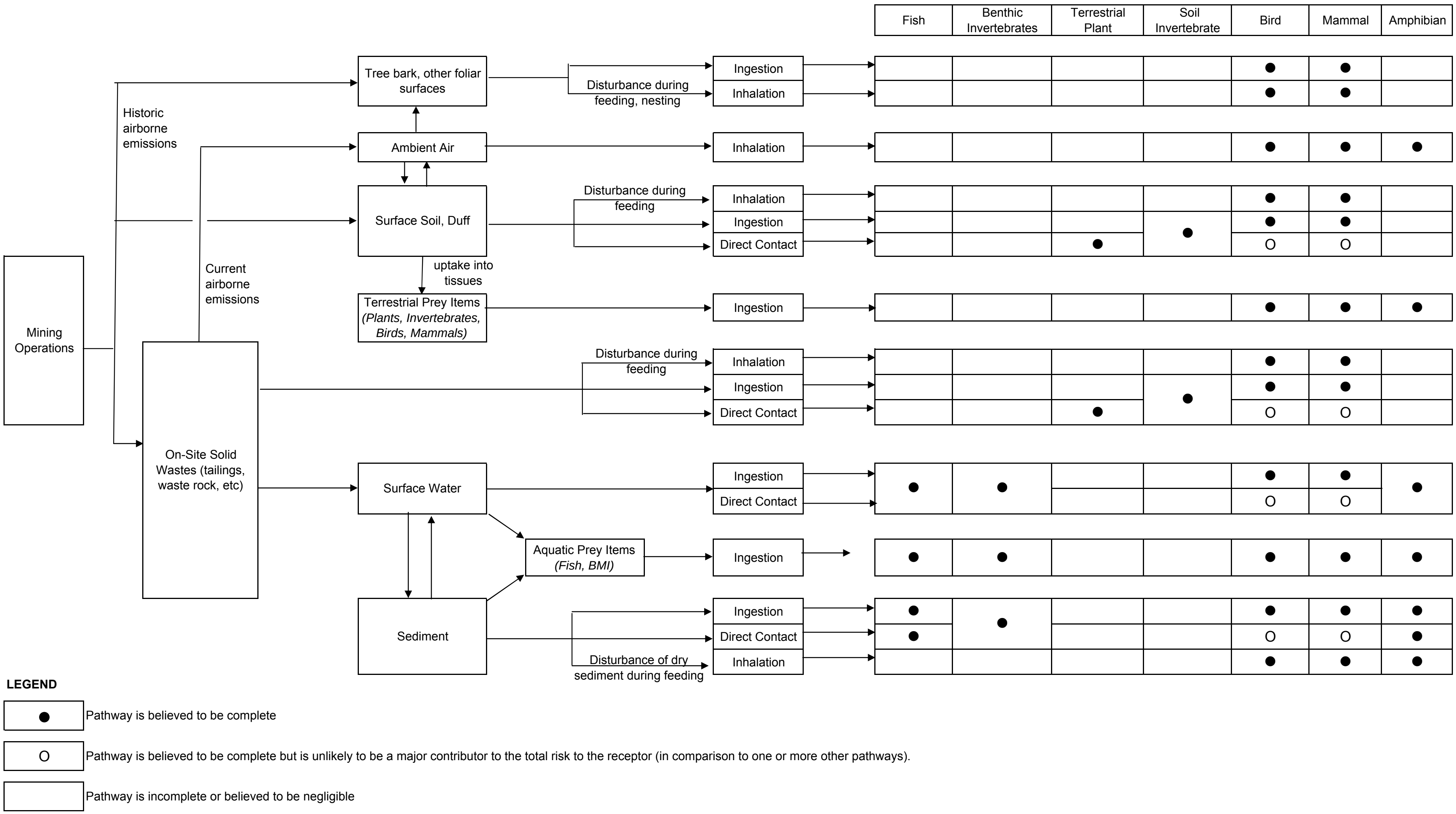


FIGURE 5-1
STRATEGY FOR SITE-SPECIFIC TESTING OF
RISKS TO BENTHIC INVERTEBRATES FROM ASBESTOS IN SEDIMENT

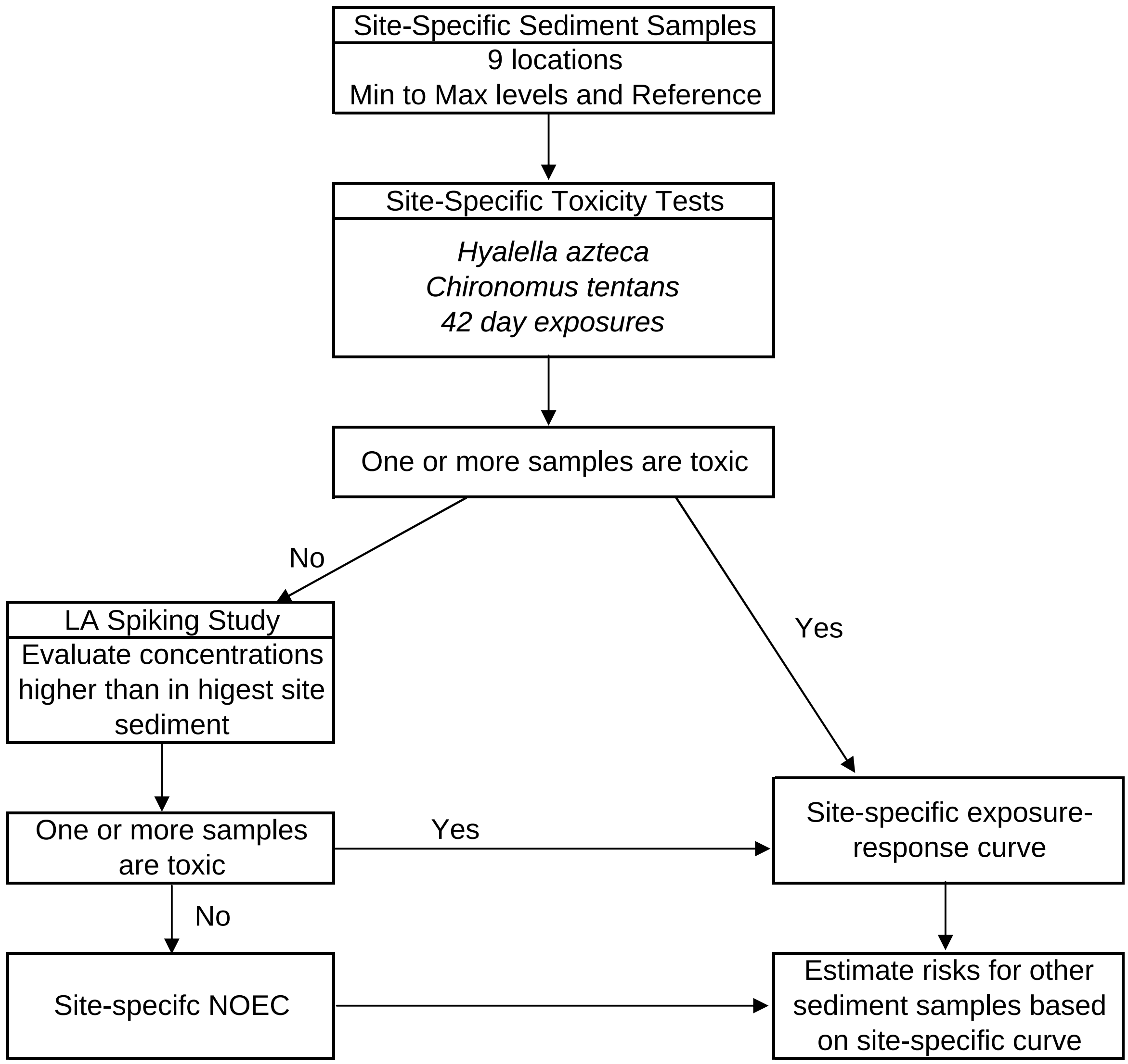


FIGURE 5-2
STRATEGY FOR SITE-SPECIFIC TESTING OF TOXICITY TO FISH FROM ASBESTOS IN SURFACE WATER

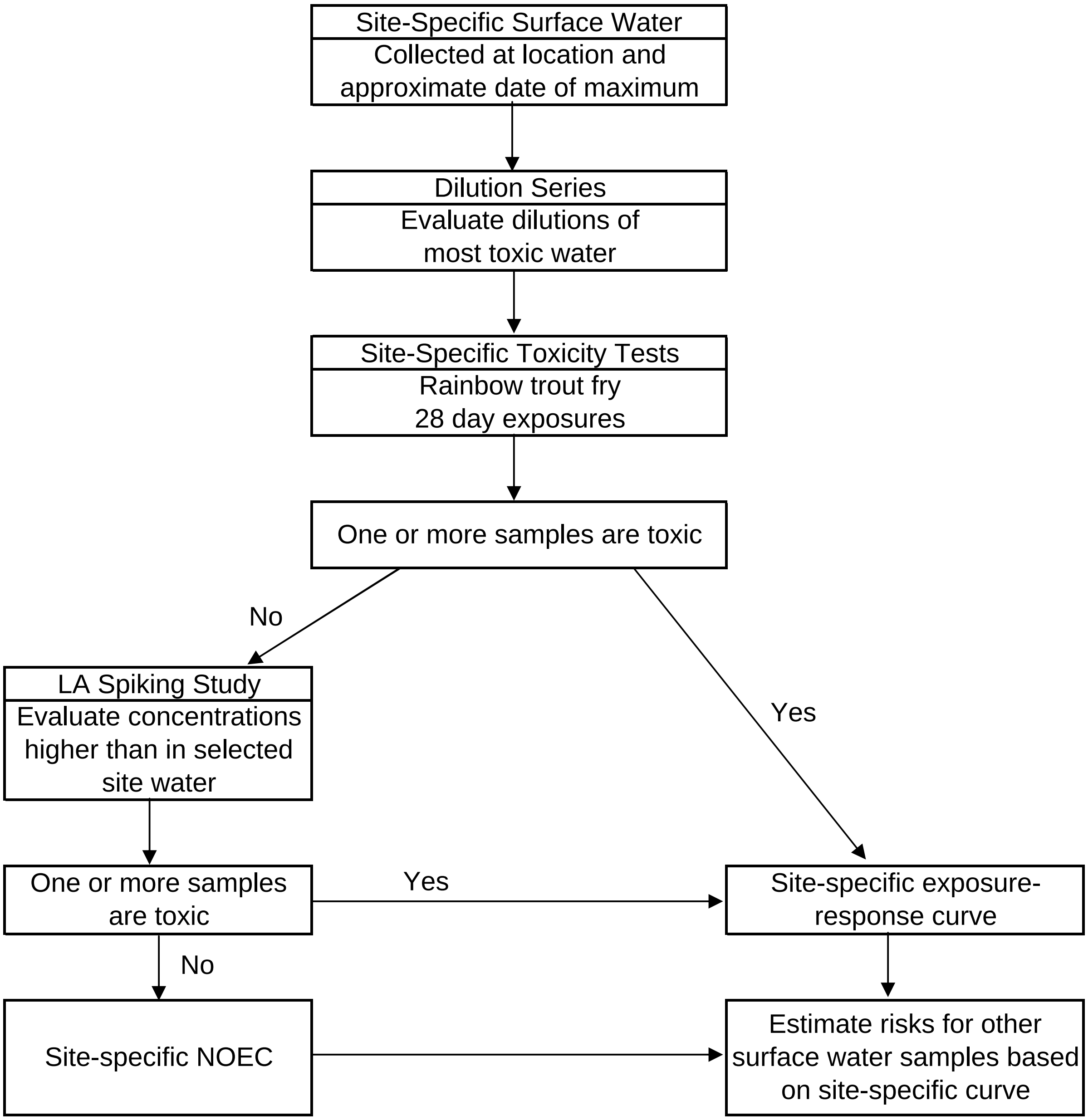
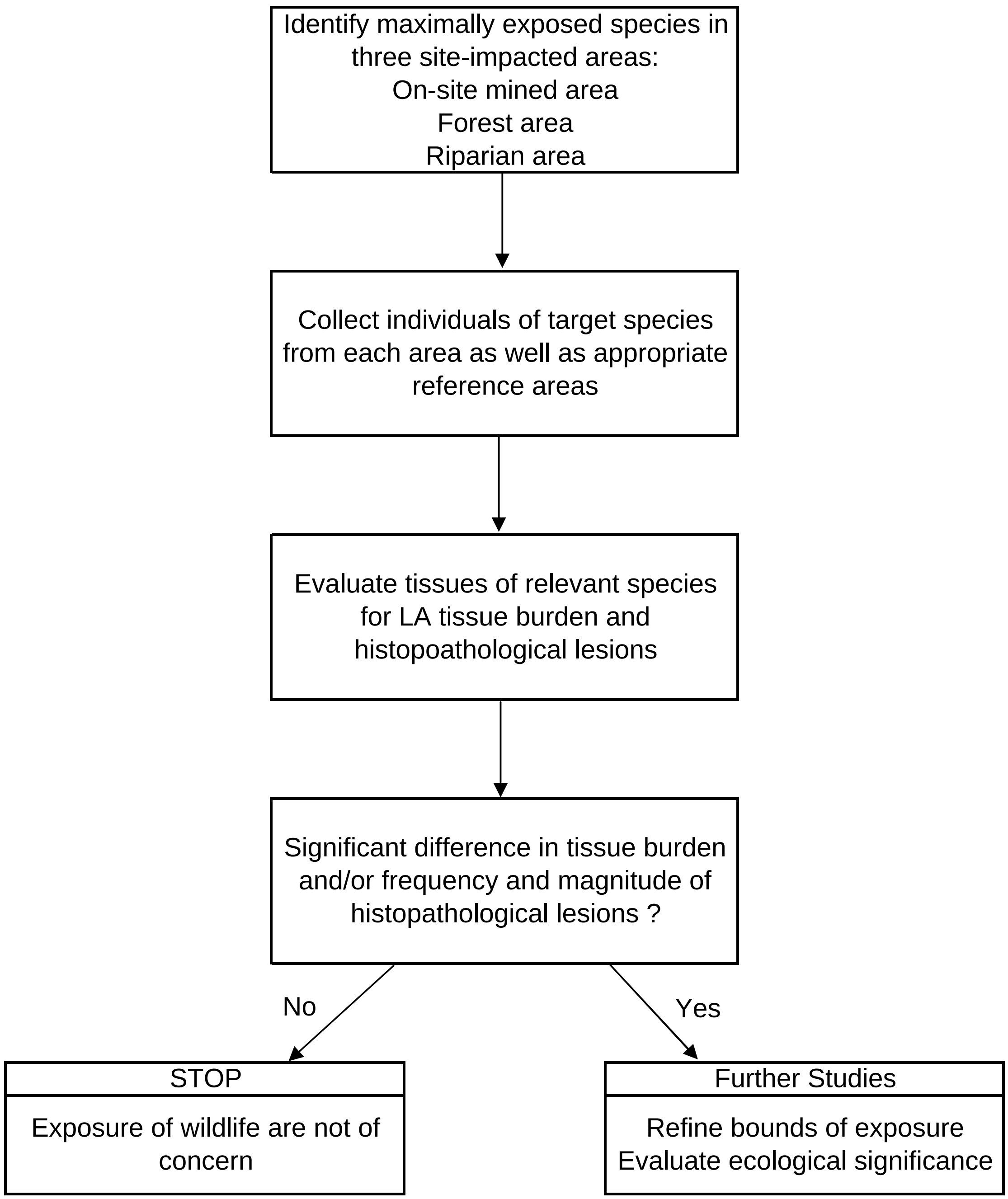
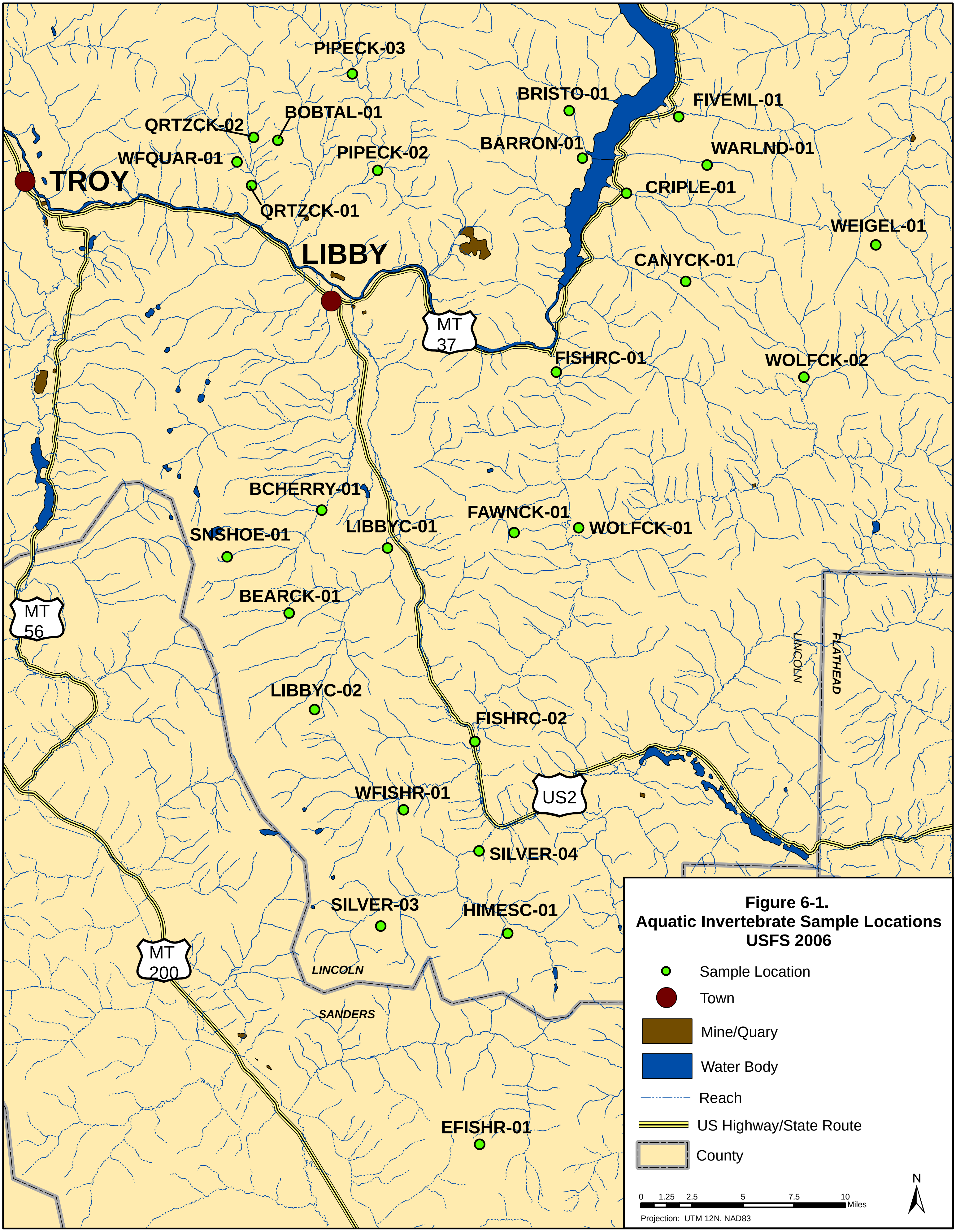


FIGURE 5-3
STRATEGY FOR SITE-SPECIFIC TESTING OF
EXPOSURE OF WILDLIFE TO ASBESTOS (ALL MEDIA)





PIPECK-03
BRISTO-01
FIVEML-01
BOBTAL-01
QRTZCK-02
BARRON-01
WARLND-01
PIPECK-02
WFQUAR-01
TROY
CRIPLE-01
QRTZCK-01
WEIGEL-01
LIBBY
CANYCK-01
MT 37
FISHRC-01
WOLFCK-02
BCHERRY-01
FAWNCK-01
LIBBYC-01
WOLFCK-01
SNSHOE-01
BEARCK-01
MT 56
LINCOLN
FLATHEAD
LIBBYC-02
FISHRC-02
US2
WFISHR-01
SILVER-04
SILVER-03
HIMESC-01
MT 200
LINCOLN
SANDERS
EFISHR-01
Figure 6-1.
Aquatic Invertebrate Sample Locations
USFS 2006
Sample Location
Town
Mine/Quary
Water Body
Reach
US Highway/State Route
County
0 1.25 2.5 5 7.5 10 Miles
N
Projection: UTM 12N, NAD83